COMPRESSED AIR

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. XI JANUARY, 1907 No. 11

Published by THE KOBBÉ CO., 90-92 West Broadway, New York.

Alphabetical Index of Advertisers, Page 13, Advertising Section.

A GOOD RELIABLE WATCH

FOR YOURSELF OR

For a Christmas Present for a Friend.

We have arranged with the manufacturers of a high grade watch to supply them to our friends at a reasonable price. We can furnish you with a regular $15.00 watch in open face or hunting case, Elgin or Waltham movements, for $11.00 and $13.00 respectively. The open face with either movement for $11.00, and the hunting case with either movement, $13.00. The open face watches are screw face and back, both are 18 size. The Elgin movement is nickel, 15 jewels in composition settings. Brequest Hair Spring Patent Regulator, sunk second dial, Roman figures, moon hands, patent center pinion, bright flat screws elegantly engraved and Damask keened and the regular Elgin main spring. These watches are cased in the well known American filled case. The Hunting cases have solid gold joints, solid gold plugs and each one contains a warranty for 20 years wear. They are all stem wind and stem set The Waltham is full jeweled throughout, both the escapement and the train. This is just the watch that any person should carry whose position requires accurate time.

We absolutely guarantee these watches to give satisfaction or money refunded. We can obtain ladies watches at prices ranging from $12 to $18. We will send a gentleman's watch free to any person sending us 15 new subscribers to the *Engineers' Review* enclosing $15 in payment for the same. Make all remittances payable to

ENGINEERS' REVIEW,

500 Caxton Building,

CLEVELAND, OHIO.

WANTED

The following back copies of Compressed Air:

Vol. 9—1904.

No. 5—July. No. 6—August.

Name prices wanted and address H., care of Compressed Air.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

JANUARY, 1907.

CONTENTS.

THE RAISING OF THE BAVARIAN

The use of compressed air in raising stranded vessels was inaugurated for the first time in the case of the 12,000 ton Allan Liner "Bavarian," which ran on Wye Rock thirty-eight miles from Quebec on the night of November 3, 1905. Almost every method known to wreckers for saving the vessel was tried and found wanting, and over $100,000 was spent in unsuccessful attempts to raise the great vessel from the Pinnacle Rock upon which she was stranded.

Through the courtesy of the North American Wrecking Company, which had charge of the raising of the vessel, we are enabled to present a description of the work, together with photographs and drawings.

The greater part of the credit for the success of the undertaking belongs to two young engineers, Mr. Robert O. King and Mr. William W. Wotherspoon. Mr. Wotherspoon remembered that Mr. King had asked him at one time how a caisson sunk in the river for the purpose of building inside of it the foundation for a pier differed from a ship without a bottom. He recalled that Mr. King remarked that he believed water could be expelled from a wreck in the same way that it was forced from a caisson and that he was convinced that the "Bavarian" could be floated by using compressed air to force the water from her hold. The two engineers discussed the matter and finally decided to take a party to visit the ship. This was done on June 27. After a careful examination of the ship it was decided that the "Bavarian" could be floated by means of the compressed air method, and the young engineers made up their minds to bid for the salvage of the vessel, which was estimated to be worth approximately $1,000,000.

Both men experienced considerable difficulty in securing the backing of men prominent in the scientific and financial world. One of the first to approve of the plan was Judge Charles F. MacLean, of the New York Supreme Court. Later the plans were submitted to Mr. W. G. Rainsford and Captain Thomas C. MacLean, U. S. N., who both agreed with Judge MacLean as to their feasibility.

It was deemed desirable to interest Canadian capital, and when a company was organized to carry out the undertaking, it included Messrs. Charles R. Hosmer, of the Canadian Pacific Railway Company; Thomas J. Drummond, of Montreal; W. E. D. Stokes, W. G. Rainsford, James B. Brady, Jacob Rubine, John A. MacDonald, J. A. Richard, William Koerper, Charles F. MacLean, of New York, and John W. MacLean, of Utica, N. Y. Capital was furnished by these men, and the two engineers were told to go ahead with their plans.

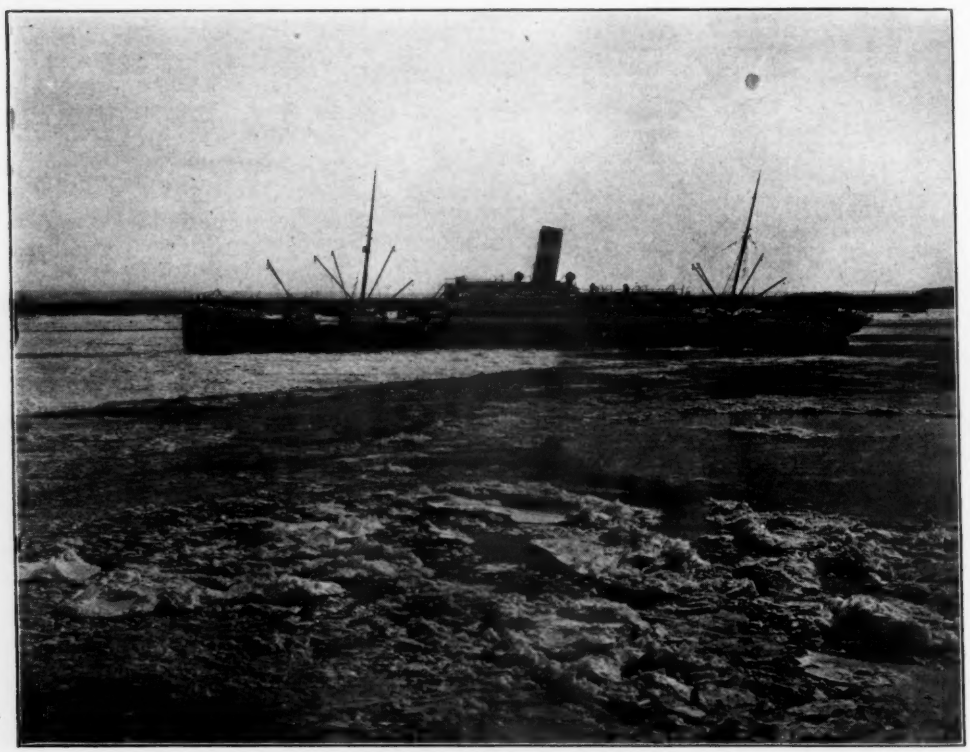
Mr. Wotherspoon, who was to have entire charge of the work up the bulwarks of the vessel, set about obtaining his crew. He had a close acquaintance with that remarkable class of men who make it their business to work in compressed air and who are commonly known as "sand hogs." He therefore collected his crew with great expedition, many of the "sand hogs" and mechanics being engaged actually as they came off shift from the different tunnels in New York.

Within thirty days these men, together with thirty more hired in Montreal and vicinity, and the air compressing plant, were taken by tugs from Quebec to the wrecked steamer. It took but a few hours to set up the machinery on deck, and the men who had been brought from New York looked the "Bavarian" over. One of these men was Richard Creedon, a tunnel worker, who was blown through the roof of the East River tunnel by the air pressure and who finally appeared on the surface of the river swimming for the nearest pier.

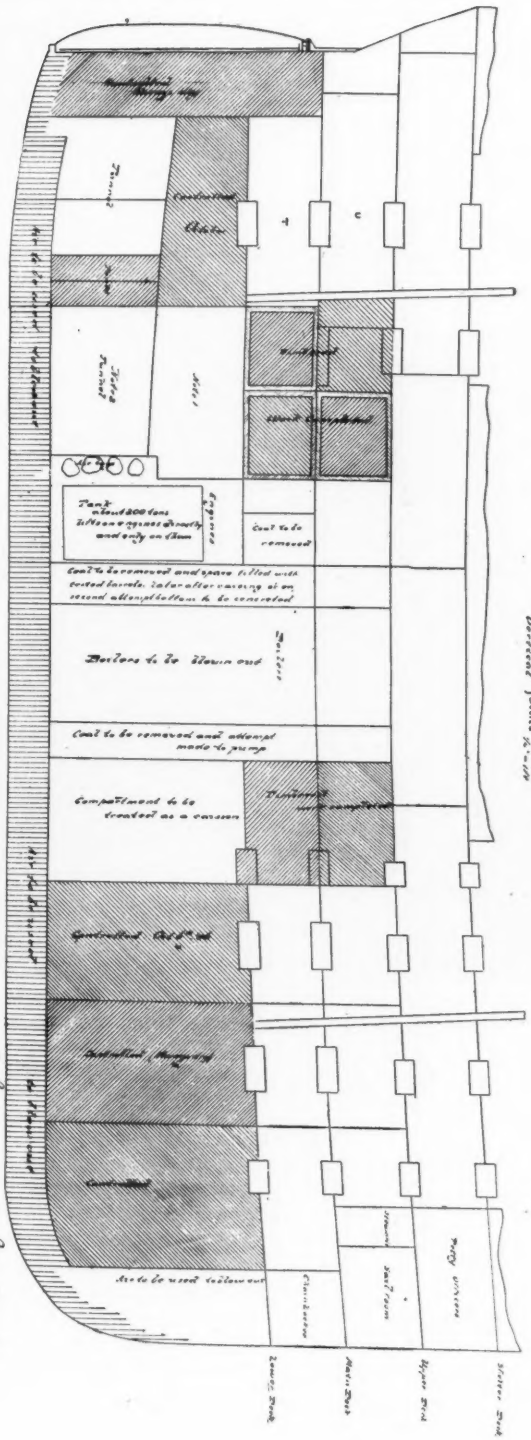
Examination had shown that the "Bavarian's" bottom amidships was in a very ragged condition. The plating had been torn by the jagged rocks, and it was impossible to patch it. The holes were so large that it would have been useless to try to pump the water out, so the preparations to force it out through the openings of the bottom were hurried forward.

All the ship's compartments were made as nearly air tight as possible. The hatches were closed by plating, which was simply laid under the hatch combing so that when the air pressure was applied the covers would be held in place. Air locks were placed on the compartments which had filled with water. As the air was forced in the water rapidly receded, and the workmen were able to stop the leaks with temporary plating.

One of the most difficult leaks to stop was in the fourth peak tank, which, in the "Bavarian," is a large ballast tank of about 115 tons capacity. An air lock was not placed on this tank, but the manhole was put in place,



STEAMER "BAVARIAN" AS SHE APPEARED BEFORE BEING FLOATED.

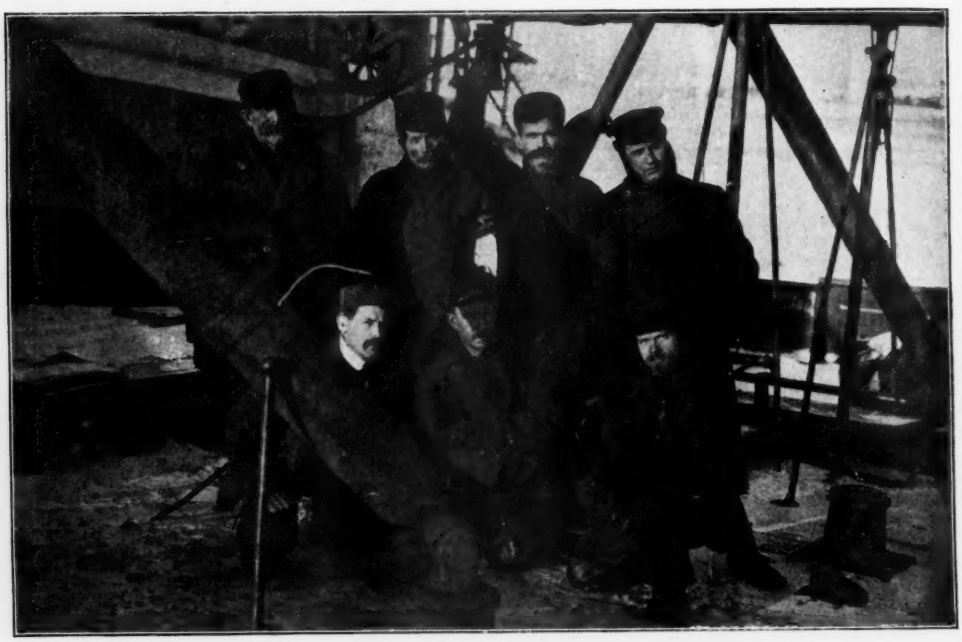


ROUGH SECTIONAL PLAN OF STEAMER "BAVARIAN," SHOWING WHERE CAISSONS WERE BUILT; HOW THE TIMBERING WAS CONSTRUCTED AND AIR PRESSURE APPLIED FOR FLOTATION.

and the air pressure applied. When the water had been driven out until the bottom was within a few feet of the surface, the manhole was taken off quickly, and the superintendent and a "sand hog" hurriedly dropped through it. The manhole cover was put on and the air applied. This time the water was forced to the bottom, and the workmen closed the leak so completely that they were able to leave the tank at their leisure.

Judge MacLean and Mrs. MacLean had boarded the ship a few days before the final soon as she floated off it would be pretty serious for all on board.

In this emergency the presence of Judge and Mrs. MacLean, of New York, proved fortunate. The weather had been very inclement, and it had been suggested that perhaps it would be better for her and Judge MacLean to go ashore before the floating of the ship. But Mrs. MacLean refused to leave the "Bavarian" until the vessel was tied to her pier in Quebec. She went among the frightened men and reassured them by her composure.



GROUP OF ENGINEERS IN CHARGE OF THE RAISING OF THE "BAVARIAN."

TOP ROW (from left to right)—MESSRS. CASHMAN, KLOUS, MURPHRE AND STEELE.
BOTTOM ROW (from left to right)—MESSRS. LEE, BAKER AND WOTHERSPOON.

touches were put on the work. It had been planned to float the vessel on November 15, on which day it was expected there would be a normally high tide, but instead a storm came on which caused a very low tide, and the floating of the ship had to be postponed. It was during this wait that the strain on the mens' nerves was most apparent. Some of the "sand hogs" and the Italians who had been hired to take coal out of the bunkers began to complain. They reminded each other that there was seven fathoms of water off the rock on all sides and that if the ship should turn turtle as It is said by those who were there that many of the workmen would undoubtedly have mutinied and gone ashore if they had not been ashamed to show the white feather when a woman remained on the ship.

There was a gale blowing on November 16 and an indication of an unusually high tide. Owing to the bad weather the tugs which had been lying alongside had dropped down the river to a more sheltered position. As the tide rose the air compressors were set to work and the full power of the plant used in forcing air into the holds of the ship. Suddenly there

was a movement in the great vessel as she lifted herself from the rocks, and a cheer went up from those on board. Five minutes later the "Bavarian" floated clear of Wye Rock in sixty feet of water. After the first few minutes all apprehension that the vessel might turn turtle or that the air pressure would not hold the water back was dispelled. The "Bavarian" floated on almost even keel and was soon in the tow of tugs on her way to Quebec.

Estimates show that the cost of salving the "Bavarian," in accordance with the plan of Mr. Wotherspoon and Mr. King, was less than one-fourth the amount expended by those who attempted unsuccessfully to raise the vessel by the use of old wrecking methods. Only $30,000 was spent, and if the salvage is half the value of the vessel, which is the law, the prize is worth nearly $500,000 to those who risked their capital in an untried scheme.

Among those who greatly assisted in the work should be mentioned Mr. S. B. McQuade, of the Ingersoll-Rand Co., who acted as expert in the compressed air work and who made several trips to the wreck, rendering valuable advice. Some seventy men were employed on the ship during the work. As may be imagined from studying the circumstances, everything in regard to the operation had to be calculated with mathematical accuracy. When work was begun by the company on September 9 it was first necessary to clean out the holds and lighten the ship of everything movable. It was found that considerable grain, cheese, pulpwood, coal and other material had been left in some of the holds, and the cleaning-out process occupied some time. Then it was necessary to solidly timber several of the compartments and render air tight the section beneath the lower deck amidships (lower hold No. 4), which was to be used as a caisson. The timbering above the caisson compartments was particularly fine, extending as far as the upper deck. This was necessary as, when the air pressure was applied, the whole weight of the ship would depend upon the upper decks. A wooden tank of about 200 tons was also built directly beneath the engines, and this being made absolutely air tight, the weight of the engines rested upon it alone. Air bags and tested barrels were secured in the bunkers and stoke hole, the whole lifting power of the air being so calculated as not to materially throw the ship out of trim when she should rise.

Exactly what will be done with the "Bavarian" in her new lease of life has not yet been decided. If she is dry docked at Quebec it will be a tight squeeze, as the entrance to the dock is only 59 feet 6 inches wide and the ship is 59 feet 3 inches beam. She may be brought to New York or taken to Halifax, or perhaps not permanently repaired until she can be taken across the Atlantic to her builders' yards. It is generally expected, however, that she will eventually resume service in the Allan Line. The future program of the North American Wrecking Company has also not been completed. The company, which has its head offices at 16 East Forty-second street, New York, is a Canadian corporation, with Messrs. T. J. Drummond (of Montreal), president; W. E. D. Stokes (of New York), vice-president, and W. G. Rainsford (of New York), treasurer.

THE ANTECOOLER, THE INTERCOOLER AND THE AFTERCOOLER

By Frank Richards, M. Am. Soc. M. E.

There is one thing to be said for these several coolers which cannot be said for any other of the products of compressed air machinery manufacturers, and that is that they do their work for nothing. Almost everything that is gotten up to do some thing costs something for the working of it. It requires either power to drive it or material to consume, or both; and then in figuring the cost of the product this power cost or material cost has to be deducted. With the coolers there is nothing required of either power or material. There can be absolutely no operative charge against the most important and effective of them, the intercooler, except for the water that flows through it, and that can't cost anything, because the water is just as usable for any purpose after as before; and yet the good work which the intercooler does is indisputable, is easily computable and is of great actual value.

The intercooler being such a bargain, I am much in favor of employing it wherever practicable, and it certainly ought to be employed much more extensively than at present. An antecooler would work on the same principle as the intercooler and just as cheaply, and

there are many cases where it could be employed with profit, especially in the summer, and in all cases where very cold water is available; and it is not at all certain that the makers of intercoolers and aftercoolers should not make and advertise and sell antecoolers also.

The intercooler, of course, implies the compound or two-stage compressor, and this, up to the undebatable pressures, is quite apt to be regarded as an unprofitable refinement or a costly complication. The status of a compressor to the intending purchaser, and also to the salesman, as to whether it should be single stage or two stage, should be precisely the same as whether it should be a 20-inch or a 24-inch machine, the ultimate question in either case being as to which will be the machine to do what we want it to do, and to do it most cheaply and most satisfactorily.

It is more or less of an open question as to what air pressures should employ two-stage compression and as to the upper limit of single-stage compression. Coming right near home we find some interesting air-compressing plants employed upon the New York tunnel work. In these plants we generally find two different systems employed and two entirely separate and different sets of apparatus; one for "high" and the other for "low" pressure, the former going up to 125 pounds and the other never expected to go above 50 pounds. For the high-pressure service two-stage compressors are, of course, employed without question, but for the low pressure there is single compression, and here might come in the question as to whether two stage should not go down to that also. In the service here referred to, the question does not really apply, because, as a matter of fact, the low-pressure compressors work most of the time at 20 to 30 pounds, but there are many places where 50 pounds is a pressure to be constantly maintained, and then the case is worth looking into.

Say that we want to constantly deliver the air at 50 pounds in any ordinary case, taking it in at 60 degrees and compressing in a single cylinder. We will take a 30-inch diameter cylinder at 400 feet piston speed. The free air capacity will be 1,963 cubic feet per minute, the mean resistance for the compression stroke—adiabatic compression—will be 27.39 pounds, and the horse power required will be 234.67. It is not necessary to say anything here about the friction of the machine, since it will be ignored equally in all the cases cited; and also the temperature at which the air is delivered does not interest us, so that the given volume of free air goes through.

Now, suppose we try two-stage compression in the case, with an efficient intercooler, working for nothing, between the stages. The diameter of the first cylinder and the piston speed is the same as before, giving an equal free air capacity. We compress in the first cylinder to 25 pounds, this pressure being fixed by the relative capacities of the first and the second cylinders and remaining constant, regardless of the final or delivery pressure. The mean resistance—adiabatic compression—will be 17.01 pounds, and the horse-power will be 145.74.

If the air is then cooled to the original temperature, the pressure being maintained, the reduced volume will be inversely as the increased absolute pressure—40:15 or 8:3, and for the second cylinder the piston area, with the same stroke, should be at this ratio, which would make it 18⅜-inch diameter. The M. E. P. for the second compression from 25 to 50 pounds would be 20.84 pounds, and the horse power would be 66.99, say 67, making the total $145.74 + 67 = 212.74$, which is apparently a saving of 9 per cent. As the intercooler would probably not cool the air quite to the original temperature, and as the friction of the machine as a whole would be slightly increased, the saving would probably be not more than 5 per cent. at the best, so that in compressing to 50 pounds it is doubtful whether two-stage compression with intercooling would not "cost as much as it came to."

It happens that the great majority of air compressors in use work at higher pressures than this, say from 75 to 90 pounds, this being the working pressure for rock drills and for most of the air-operated tools of the shops. It is important, therefore, that for the class of compressors most numerously employed the minute economies be investigated and that economies not absolutely minute be adopted by those who work for profit.

With the same cylinder data as before, 30 inch diameter and 400 feet piston speed, the M. E. P. in compressing adiabatically to 75 pounds will be 35.23 pounds and the horse power 301.85.

Say, now, that we try two-stage compression on the same job, compressing in the first cylinder to 30 pounds. The M. E. P. for this compression, adiabatic, will be 19.4 pounds, and the horse power 166.3. For the second cylinder the diameter would be 17.32, the M. E. P. 34.56, and the horse power 98.7, making the total horse power 166.3. + 98.7 = 265. Here the difference is a little over 12 per cent., which is evidently worth saving, and if you don't save all of it you save a couple of years of savings bank interest anyway, all in a second or less. The percentage of power cost of single-stage over two-stage compression, with perfect intercooling in this case, is nearly 14 per cent.

To compress to 90 pounds, single stage, the M. E. P.—adiabatic—would be 39.18 pounds and the horse power 335.71. Using the same two-stage cylinders as before and compressing to 90 pounds, the work of the low-pressure cylinder would be precisely the same as before and the horse power the same, 166.3. For the high-pressure cylinder, compressing from 30 to 90 pounds, the M. E. P. would be 43.41 pounds, and the horse power 123.97, making the total horse power 166.3 + 123.97 = 290.27, or nearly 14 per cent. below that for single-stage compression, while in terms of the two-stage compression the excess of horse power for the single stage would be more than 15½ per cent.

The gain here, all for nothing, would seem to be beyond question, and this for the common every-day working pressures. The adoption of the two-stage compressor would seem to be imperative for any permanent plant which was expected to do its work as cheaply as possible. If a man will not take such profits as this, which offer to keep dropping into his pocket every minute his compressor is in operation and with nothing going out, you don't have to even oil an intercooler—it can't be profit that he really is looking for.

With the intercooler treating its employer so generously, the employer should not be niggardly. The intercooler should be made of liberal capacity, so that it can do its work leisurely and thoroughly, and customers should not be educated to expect to get the intercooler for next to nothing because its work costs nothing.

The intercooler does more than reduce the horse power required for compression. It does much to remove what is, in some cases, the most serious objection to the employment of compressed air. Dry air can't freeze up, and the intercooler helps to dry the air. This is the special function of the aftercooler. There is practically no such thing as "dry" air, and the dryness of air is always comparative. When the air is at its highest pressure, which it is just when leaving the compressor, if it can then also be reduced to its lowest temperature, its moisture-carrying capacity will be at the minimum. It will be wet air; so wet that the water will be dropping out of it. The water should here be given every chance to drop out, and when further along its pressure falls, and its temperature rises, this same air, without giving up another drop of the moisture that is in it, becomes "dry air," and remains dry air while in use.

If the air ,with the heat of the final compression in it, is not cooled, and thus dried before it starts on its journey through the pipes, it will begin dropping the water out of it as it goes along, and it will be "wet air" instead of dry air all the way. In freezing weather in out-of-door work, as in quarries, the moisture will freeze, little by little, to the interior of the pipe and soon choke it up, or some of the ice will be carried along to an elbow or to some depression or pocket and form a solid obstruction there. One peculiarity about ice is that when two pieces or particles come together, no matter what the temperature surrounding them, and without being forcibly pressed together, they freeze together solid. There are always meeting-places for the ice particles in the pipes and passages, and there they solidify and trouble follows. When the moisture is not in the air the air can't freeze up, and nothing can be choked by ice. In weather that is not freezing, the moisture which is in excess still makes constant trouble. It collects in low places and then it starts in a body, and we have water-hammer and leaky joints. The changes in temperature in the pipes from the alternate hot and cold condition of their contents when the air is not cooled at the compressor, make expansion and contraction strains in the pipes, which result in leaks, if not breakages, of the line.

One most serious effect not generally realized in the rock drills or other tools or machines which the air is used to drive is in the interference with the lubrication. It is generally understood that oil and water will not

mix, but all the consequences of this are not realized. It means that whether oil or water first occupy the surfaces (the internal surfaces) of a machine, the other is effectually excluded from those surfaces, so that when the moisture of saturated air condenses upon surfaces requiring lubrication, the oil can't get at those surfaces, and lubrication is defeated. The surfaces wear or cut, and while they are working the drills take more power to drive them on account of the abnormal friction.

All these troubles with uncooled air are matters of repeated and constant experience, and the beneficent effects of immediate and thorough aftercooling and drainage of the air at the compressor are also matters of evidence and record. Even though the work of the aftercooler can't be paid for—there is no place to spend the money on it after you have it—its service cannot be dispensed with without constant loss. Money is often lost by unwise purchases, but in this case the loss would be in *not* buying the aftercooler.

THE LATTA-MARTIN PNEUMATIC DISPLACEMENT PUMP

The compressed air displacement pump is coming more and more into general favor owing to the fact that it is absolutely automatic in its operation and will operate efficiently at almost any distance from the source of power, thus permitting of several pumps being installed in different places and operated from a central compressed air power plant. Among other advantages possessed by this type of pump should be mentioned the fact that it will handle muddy or gritty water without in any way impairing its efficiency, owing to the fact that it possesses no pistons, plungers, stuffing boxes, glands or other parts in its mechanism which might be injured thereby.

In addition to the advantages enumerated above, the Latta-Martin Pneumatic Displacement Pump possesses some qualities which place it in advance of other types of compressed air displacement pumps. Chief among these is the fact that it contains no floats, which have always been a source of trouble in other pumps of this type.

The cross-sectional view shown in Fig. 1 illustrates very clearly the details of the construction and operation of the Latta-Martin Pump. In general the pump consists of two plain cylinders with a valve mechanism attached to their heads. This mechanism comprises a main valve and an auxiliary valve, shown in detail sections, each operated by the air pistons, and an oscillating slide valve. A, under the main valve. B and B are plain covered copper buckets which, when the pump is installed, become and remain full of water. Particular attention is called to the fact that these are not floats, the buckets being suspended on steel rods connected to steel levers which operate the oscillating slide valve A. The buckets are enclosed in galvanized iron housings, C and C, which are connected to a header on top of the cylinders by pipes E and E.

The operation of the pump is as follows: When it is submerged in water, the cylinders at once fill by gravity through the foot valves, R and R. The main valve mechanism, as shown in the detail, operates the slide valve A_2, and opens and exhausts at proper intervals the live air ports J and K. For instance, in starting the pump live air travels down through the air inlet S into the open port J and into the left hand cylinder, which is full of water. This compressed air forces the water, by displacement, down and out through the discharge O, up through the check valve P, and into the water main at Q. When the water has been forced from the left hand cylinder down to a level slightly above the opening O, the bucket B, which is full of water, is supported only in a column of air, while the bucket in the opposite cylinder on the other end of the lever is immersed in water and therefore weighs almost nothing. The bucket in the left hand cylinder then becomes a dead weight, pulls down the rod and lever to which it is attached and operates the slide valve A, which throws live air through port F and F′ to one end of the auxiliary piston L. At the same time A opens an exhaust port from the opposite end of auxiliary piston L, through port G′. The piston L moves its slide valve, which throws live air through port I and I′ to one end of the piston in the main valve M. At the same time it opens exhaust port H and H′ from the opposite end of the main piston in M. The latter carries with it the slide valve A-2, which crosses the port J, and exhausts the compressed air, which has done its work in the left hand cylinder, and throws live air into the right hand cylinder through the port K, while the exhaust from the other cylinder passes out

through the exhaust fittings T and T'. While air has been forcing water from the right hand cylinder the left hand cylinder has been exhausted and has become full of water by gravity through the foot valve R, the operation taking place alternately between each cylinder, giving a continuous flow of water.

Attention is called to the accessibility of the valve mechanism for repairs. By removing the bolts around the header on top of the cylinders, as shown in Fig. 1, the entire valve mechanism, together with housings and buckets, may be removed without disconnecting any water fittings. It will be appreciated that there is no possibility of the pump getting on dead center and that it is capable of handling the muddiest and grittiest water, as all valves, including the oscillating slide valve, never come in contact with the water. The absence of wear inside the cylinders is also to be noted, where there are no working parts except the buckets, and these do not touch or come in contact with the housings within which they operate. Long life is insured from the fact that the travel of the buckets is but 2 inches, travel of main slide valve 2 inches, auxiliary valve 1 inch and oscillating slide valve ½ inch per stroke. At the highest speed at which these pumps are operated this stroke does not take place over six times per minute.

An installation of such an equipment has been made for the water works system of the city of Hickory, N. C. With it the city is pumping its water supply from the South Fork River, at a distance of three miles from the power plant, which is located inside the city limits on the line of the railroad, using a 3-inch transmission line, and the displacement pump at the river forces back to the city a 10-inch stream of water against a total head of 320 feet. This installation gives one of the longest and most severe tests of transmitting air for pumping purposes that has ever been made. It has now been in operation for about a year and is giving most satisfactory results. By it the city has been able to eliminate establishing a pumping plant at the river and so save the cartage of fuel to that point and the necessity of keeping a machinist at the river. The water system is now arranged so that the subsiding and filter basins and clear water well are all located at the power plant inside the city limits, requiring only the services of one day man and one night man to run the entire plant.

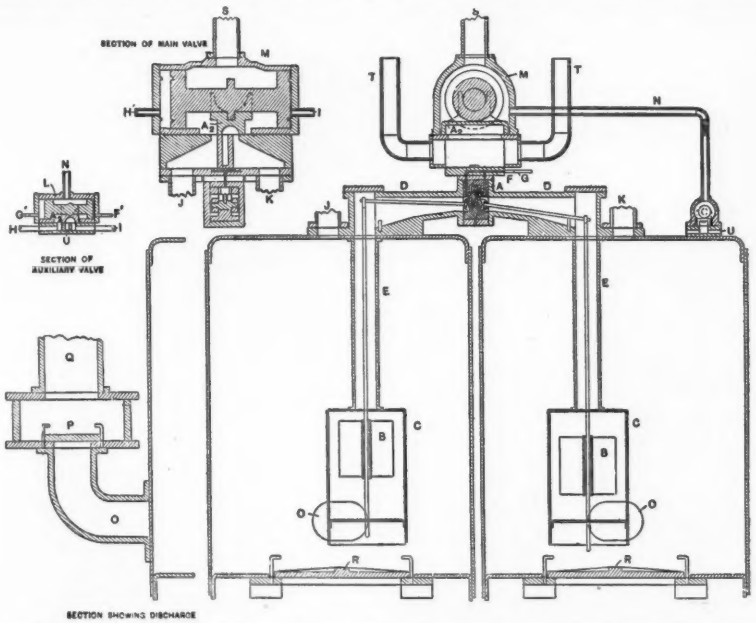


FIG. I—SECTIONAL VIEW OF LATTA-MARTIN PNEUMATIC DISPLACEMENT PUMP.

The pneumatic displacement pumps are manufactured by the Latta & Martin Pump Company, Hickory, N. C. The eight standard sizes range in capacity from 25 gallons per minute, under a pressure of 150 pounds, to 1500 gallons per minute at 90 pounds. The smallest has cylinders 14 inches in diameter by 36 inches high, and the largest 48 inches in diameter by 60 inches high. The pumps are made to order, for any capacity and any pressure.

CLEARANCE IN A COMPRESSOR, AND ITS RELATION TO VOLUMETRIC EFFICIENCY

By D. W. Hering.

In any list of the merits and demerits of different types of compressors, one of the defects is waste space or clearance. By this is meant the space between the piston at the end of the stroke and the tank or pipes containing the air at its final pressure. It consists of a short space between the piston and the cylinder head when the stroke is completed, and a small necessary space required for the placing and working of the valves. Small as this space is in fact, being in well constructed compressors from one-fifth of one per cent. to one per cent. of the entire volume of the cylinder, it interferes somewhat with the volumetric efficiency of the compressor, and the more so if high pressure is required.

In machines of inferior construction the clearance is larger and the efficiency is correspondingly diminished. If the piston must nearly complete its traverse before the requisite pressure is reached, it is evident that the portion of the compressed air in the clearance space will be a considerable part of the whole, and only the remainder will be delivered to the reservoir. Effective cooling of the air within the compressor cylinder aggravates this evil, for the colder the air the smaller will be the total volume when the maximum compression in the cylinder is accomplished, while the volume of air in the clearance is not diminished, and therefore this is a larger proportion of the whole when cold than when hot. It is plain, too, that a large clearance space might result in no air being forced out of the compressor cylinder even with moderate compression. In cylinders of ordinary proportions, compressing to seventy-five pounds gauge, if the space between the piston and the head at the end of the stroke is one-sixteenth of an inch, the clearance loss of volume is from one to five per cent. of the air when compressed.* The only real objection to the clearance space, however, is this of diminished quantity of air delivered, and not, as has been sometimes supposed, a waste of power, for the work expended upon the air in the clearance is returned by it in expanding against the receding piston. In an extreme case, where the maximum pressure would be reached just at the end of the stroke and no air would be delivered, the re-expanding air would return all the power applied except that necessary to overcome the frictional and thermal losses, and the machine might run along continuously with little power applied, with considerable compression within the cylinder, and with nothing accomplished. With some cooling of the cylinder, the air in expanding might fall in temperature below that of the external air and so, in some degree, cool the incoming air, which would be an advantage by lessening the work of compression.

When the piston has moved to its furthest position in compressing and expelling the air within the cylinder, the clearance space will contain air at the maximum pressure. Upon the return of the piston the air in the clearance space expands until its pressure is equal to that of the external air or slightly less, before more air will enter the cylinder. The ratio, in hundredths, of the volume of the clearance space to that swept through by the piston in moving from one end of the cylinder to the other, expresses the amount of clearance in per cent. In discussing this subject we may follow, in part at least, the method of Von Ihering. **

Calling the volume of the clearance space V_c, that of the piston displacement V_a, and the clearance C, we have $C = \frac{V_c}{V_a}$, or $V_c = CV_a$ .....(A)

In the accompanying diagram (Fig. 1), taking as usual, horizontal distances to represent volumes, and vertical, pressures,

Fig. 1.

Let AE = V_a = volume of piston stroke.

EM = CV_a = volume of clearance,

FM = V'_c = volume to which air in clearance space expands as piston returns towards A, when pressure falls to P_a,

AB = P_a = pressure of the atmosphere,

ED = P_1 = maximum pressure in clearance.

AF = V_x = volume of air drawn into cylinder.

Then BCC′ represents the compression curve, DG the expansion curve from a maximum pressure of ED in clearance, and D′G′ the expansion curve if the maximum pressure in clearance were equal to ED′. The higher the pressure of expulsion, *i. e.*, the ordinate of C or D, the nearer G approrches B, or V_x approaches zero. Further, when the piston

*W. L. Saunders.

**Die Gablaese, Part II, Chap. IV.

begins to recede, let V_c be the volume of air in the clearance space, P_1 its pressure, T_1 its temperature; and at the end of its expansion suppose V_c has changed to V'_c, P_1 to P_a, and T_1 to T'_1.

The volume to which the air will expand will depend upon whether the expansion is isothermal, *i. e.*, with no change of temperature; or adiabatic, *i. e.*, with no gain or loss of heat; or intermediate between these, which we call polytropic.

(1) Suppose the expansion to be isothermal. Then $T_1 = T'_1$, and by Boyle's law the product of pressure and volume at the

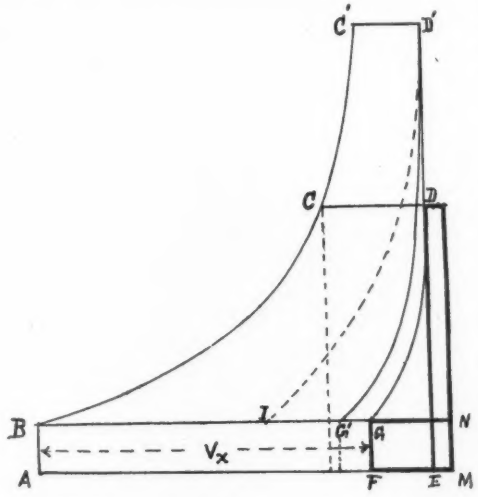


FIG. I.

beginning of expansion equals the product of volume and pressure at the end, or $P_1 V_c = P_a V'_c$, whence, if we call the ratio of compression $\frac{P_1}{P_a} = r$, we have $V_c' = \frac{P_1}{P_a} V_c = rCV_a$ .....(B)

The volume of new air that will be drawn into the cylinder is the difference between V_a and V'_c, which we may call V_x; then

Vol. of piston sweep	+	Vol. of clearance	=	Vol. to which air in clearance expands	+	New air to fill cylinder

$$V_a + CV_a = V'_c + V_x$$

Whence, $V_x = V_a (1 + C) V_a - V'_c$ which becomes, by introducing the value of V'_c from equation (B),

$$V_x = V_a (1 + C - rC) = V_a \left[1 - C (r - 1)\right] \text{.....(C)}$$

The ***volumetric efficiency*** is the ratio which the volume of air admitted at each stroke bears to the actual volume traced by the piston, or $\frac{V_x}{V_a}$. Calling this ratio E_v, we have from equation (C)

$$E_v = 1 - C (r - 1) \text{.....(D)}$$

E_v may be anything from unity, which would be its value if there were no clearance and no leakage with free admission of air, to zero, when no air would be driven from the compressor into receivers, at the maximum pressure. In this latter case the air would re-expand so as just to fill the compressor cylinder when its pressure fell to that of the external air. No new air would be taken in, or $V_x = O$. From equation (D) we see that this would be the case, or $E_v = O$, if $1 - C (r - 1) = O$, or $C = \frac{1}{r - 1}$ and $r = \frac{1 + C}{C} = \frac{1}{C} + 1$ .....(E)

From this equation we may see at what ratio of compression, with a given clearance C, a compressor will cease to deliver air, and from equation (D) we may determine the ratio of compression that will result in delivering any stated proportion of air. For instance, if $C = .02$, equation (E) shows that $r = 51$, and if $C = .05$, $r = 21$, and in this latter case it would be useless with this compressor to try to get air at a pressure of 21 atmospheres, or 294 pounds gauge pressure.

To find at what ratio of compression a definite fractional part of the volume of the piston sweep would be delivered at each stroke, put E_v equal to this fraction, in equation (D) and solve for r. Suppose, for example, that with a clearance of five per cent. we wish to know how high a pressure we could maintain with a volumetric efficiency of fifty per cent. Here $C = .05$, $E_v = \frac{1}{2}$ and equation (D) gives $r = 11$; *i. e.*, the air may be compressed eleven fold, or to 147 pounds gauge pressure if it is initially at standard pressure of 14.7 pounds per square inch. In such case it would require two strokes of the piston for every cylinder full of free air delivered under pressure, and the process would be correspondingly slow.

If the ratio of compression, r, and the clearance C, are both determined in advance, then equation (D) gives at once the volumetric efficiency. With a high grade machine

suppose the clearance is one-half of one per cent.; *i. e.* $C = \frac{1}{200}$, and the air is to be compressed to 14.6 atmospheres, *i. e.*, $r = 14.6$, or the final pressure is to be 200 pounds gauge; equation (D) gives $E_v = .932$ or *93.2* %.

These equations and results are on the supposition that expansion in the cylinder is isothermal. As the air expanding against pressure would fall in temperature, the expansion could not be isothermal unless the air underwent some heating while expanding. But in practice not only does this not occur, but with a water jacketed cylinder, whatever effect the jacket has in cooling applies on the expansion side of the piston as well as on the compression side.

(2) Suppose the expansion to be adiabatic: We may derive similar formulas. Using the same notation as before,

$P_1 V_c = RT_1$ and $P_a V'_c = RT_1$, where R is Regnault's constant whose value is 53.2 if pressure is pounds per square foot, volume is cubic feet, and temperature is in Fahrenheit degrees. Of course where *ratios* of pressures or volumes or temperatures are concerned it does not matter in what units they are expressed. From these two equations we have $\frac{P_1 V_c}{P_a V'_c} = \frac{T_1}{T'_1}$ and $V'_c = \frac{P_1}{P_a} V_c \frac{T'_1}{T_1}$, in which $V_c = CV_a$. From the thermodynamics of gases $\frac{T_1'}{T_1} = \left(\frac{P_a}{P_1}\right)^{1-\frac{1}{k}}$ in which k is the adiabatic exponent *1.41*; hence $V'_c = CV_a \left(\frac{P_1}{P_a}\right)^{\frac{1}{k}}$

$= CV_a r^{0.7092}$

Also, as before, $V_a + CV_a = V'_c + V_x$

whence $V_x = (1 + C) V_a - V'_c$

$= (1 + C) V_a - CV_a r^{0.7092}$

or $V_x = V_a \left[1 - C(r^{\frac{1}{k}} - 1)\right]$ .....(F)

This gives for volumetric efficiency,

$E_v = \frac{V_x}{V_a} = 1 - C(r^{\frac{1}{k}} - 1)$.....(G)

The values of E_v approaches unity, its highest possible value, as C and r become smaller. E_v become zero if

$1 - C(r^{\frac{1}{k}} - 1) = 0$ or $r^{\frac{1}{k}} = \frac{1 + C}{C}$

whence $r = \left(\frac{1 + C}{C}\right)^k$ ..... (H)

The similarity of equations (F), (G), and (H), with equations (C), (D), and (E) is readily apparent. Apply them to the former example, with a clearance of two per cent., equation (H) gives $r = 255.6$ and with $C = .05$, $r = 73.17$ as the limiting ratios of compression at which any air would be forced into a receiver. For the pressure under which this compressor with five per cent. clearance would deliver one-half of the cylinder contents at each stroke, by putting E_v in equation (G) equal to ½, we find $r = 29.3$, which corresponds to a gauge pressure of 416 pounds per square inch. If the compressor has a clearance of only 1-200 part, and the compression is carried to 200 pounds gauge, *i. e.*, $r = 14.6$, the volumetric efficiency shown by equation (G) is $E_v = 0.972$ or 97.2 %. In like manner values could be computed for any per cent. of clearance, or any ratio of compression.

(To be concluded.)

THE EFFICIENCY OF THE TURBINE AIR COMPRESSOR

Some highly interesting results have been obtained with a Rateau air compressor, built at Baden by Messrs. Brown, Boveri & Co. A description of the plant, with the figures obtained on test, is given in a recent issue of the *Schweizerische Bauzeitung*. The compressor in question was designed to supply one cubic metre (35.3 cubic feet) per second, at a pressure of 5 atmospheres, when running at 4,000 turns per minute. Actually it was found necessary to increase the speed to 4,250 turns per minute in order to get the desired pressure, and the discharge was then 1.13 metre per second (2,394 cubic feet per minute). The air passed through the machine was measured by making the compressor draw its supply from a large reservoir. The air entered this through a gauged orifice, the amount passed being deduced from the pressure registered by a water-gauge fitted to the reservoir. The result thus obtained is said to be correct to within 1 per cent. The efficiency was measured in two ways. First, by the ratio of the work theoretically necessary to draw in, compress and deliver the air under the actual conditions of the test, to that actually expended on the compressor shaft. Reckoned in this way, the efficiency was 69.8 per cent. In many practical applications, however, the com-

pressed air is necessarily cooled down to atmospheric pressure again before it is made use of. Hence the efficiency of this compressor has also been reckoned on the basis of the ratio of the work necessary to compress the air isothermally to that actually expended. Thus reckoned, the efficiency amounted to 61.5 per cent.; a figure which, it is asserted, has never been surpassed by a reciprocating compressor in which the measurements have been made with due care. Too commonly in testing reciprocating compressors the quantity of air passed is estimated from the indicator diagram. Tests made by quite independent and competent observers have shown that the error thus made may range between 4 and 10 per cent. When due account is taken of this fact, it is claimed that the turbine compressor is fully as efficient as the best of the reciprocating compressors if the air after compression has to be permitted to cool before it is utilized.

DUPLEX AIR COMPRESSORS

BY TECUMSEH SWIFT.

I am tolerably familiar with "write-ups", and there seems to be a plenty of them, and I understand pretty well the why of them. Just now I am anxious to find out about "write-downs"; what they are for and what is intended to be accomplished by them.

The cut herewith, which I have seen lately in more than one technical journal accompanies and is intended to illustrate and explain a "write-down" of the duplex air compressor. It is a wonder to me in the first place that any one could write such a thing and in the second place that it could appear on the page of a reputable and well-informed journal; but there it is.

I might as well speak straight out what I think about the matter. The article from which the above cut is taken is not signed and nobody apparently is responsible for it, except as the editors endorse it by publication, but it seems to be put out in the supposed interest of builders of air compressors which are not duplex, the assumption apparently being that anything derogatory to the duplex is necessarily an endorsement of the straight line, or any other old machine.

Those who are familiar with the best air compressor practise of the day, do not need to be told that in all the large and more or less permanent installations of air compressors, and in all plants where the best steam economy and the most absolute reliability of service are sought, the air compressors employed are precisely those which are attacked in the article here referred to: Corliss cross compound condensing machines.

Of the 80 air compressors now running day and night upon the tunnel and railroad work

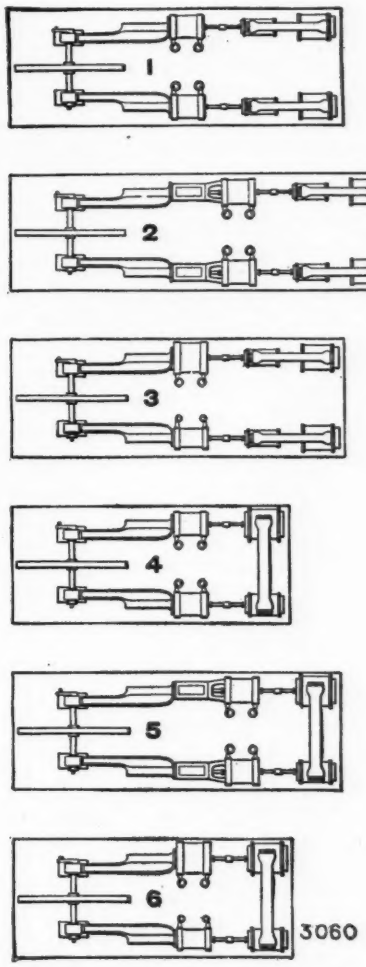


FIG. 1.

in and around New York city, most of them are of this type. It has been recently computed—the figures can be produced— that one of these compressors—Corliss cross-compound condensing—in its economy of steam as compared with the steam consumption of Meyer slide valve, straight line compressors, con-

siderably more than pays for itself in a single year.

The cut herewith is said to represent the six different types of duplex air compressors with compound air compression. These are:

1. Twin tandem compound air cylinders and twin simple steam cylinders.
2. Twin tandem compound air cylinders and twin tandem compound steam cylinders.
3. Twin tandem compound air cylinders and cross-compound steam cylinders.
4. Cross-compound air cylinders and twin simple steam cylinders.
5. Cross-compound air cylinders and twin tandem compound steam cylinders.
6. Cross-compound air cylinders and cross-compound steam cylinders.

The collection either indicates that the compiler is not accurately formed as to air compressor practise or it must be taken as a fine example of the ingeniously disingenuous. These six different combinations are, of course, all possible, and samples of each may have been built, but we are talking here—or what's the use of talking at all—rather about the actual machines of the present and the immediate future, about machines now to be built and sold; and who would build, or who, sufficiently informed, would buy *duplex* machines with *tandem* compound cylinders either steam or air, four cylinders to do the work of two, or, as in No. 2, eight cylinders to do the work of four. We have to do, therefore, only with No. 4 and No. 6, as representing the now possible machines.

One charge made in all apparent seriousness against the duplex machines is that if any part of a machine is so deranged as to make stoppage necessary, the entire machine must stop. Is not this equally true of all straight line machines? If the steam cylinder gives out the air cylinder can't run. If one connecting rod box heats up and melts the babbitt out, you can't run with the other rod.

The duplex machine is a single machine, as much so as the straight line machine, except that it is usually a larger unit. The duplex machine often represents the capacity of three or four straight line machines, and for probability of stoppage for repairs or replacement, the one is properly only comparable with three or four of the other, instead of with a single one.

Not long ago I was privileged to make a tour of all the compressor plants employed on tunnel and railroad work in and around New York, where the 80—the precise number—of compressors spoken of are running, and not one of these machines was out of order or undergoing repairs. Nearly everyone was running up to or above its full rated capacity, and every one not so running was ready to start at any moment if required.

This talk about the probability of stoppage for breakdown or derangement might well originate with the builders of an inferior line of compressors, it being their familiar experience; but, as a matter of fact, while the work of the air compressor is onerous the standard machines are built to meet the conditions, and breakdowns, derangements and stoppages for repair are much more frequent, and, in the bulk, much more costly for the common straight line than for the high class duplex machines.

"The generally observed friction of the duplex machines," it is said, "exceeds by about 5 per cent. the friction of two machines working separately." I understand that the capacity of the two machines here referred to is equal to that of the one duplex machine. As to the friction of the machines, everybody except the writer of the above knows that precisely the reverse is true. Richard's "Compressed Air" says that the friction of large Corliss duplex machines is often less than 5 per cent., while that of straight line compressors is seldom less than 10 per cent., conclusions deduced from numerous sets of indicator cards and which have gone unchallenged for ten years.

"For any given output of air they are more expensive in first cost and up keep." This, too, is misleading and as to the up-keep untrue. The machine represents a little more expense at the beginning to make a larger profit all along. The larger cost of the compressor is largely offset, anyway, by the smaller boiler cost.

It is not necessary to reproduce here the plans of the straight line compressors which accompanied the others to show how much less floor space is occupied by the straight line machine. These machines are not planted in

Wall Street, but usually where land costs nothing and roofs and floors but little. The habit which the duplex machines have of insisting upon sufficient floor space to make every part of the machine perfectly accessible when in operation, and for getting or taking out any part without disturbing the rest, is one of the best things about them. The straight line machines are crowded together and internally inaccessible enough at the best, and the way in which they consent to be stuck away in dark and dirty corners, inviting contempt and neglect is a most deplorable characteristic. I do not willingly say anything against the straight line machines of any make, for they have been the pioneers and have done excellent work in promoting and establishing the compressed air industries, but the machine of to-day is also to be respected, and certainly deserves to be protected from misleading misrepresentation. It may be well to remember that a "write-down" of any machine is not usually a "write-up" of any other.

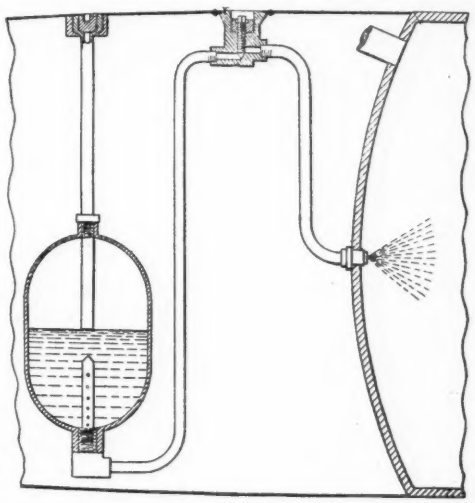
A NEW METHOD RE-HEATING COMPRESSED AIR FOR USE IN TORPEDOES

Re-heating compressed air for the purpose of increasing its volume and so enabling it to do more work than would be possible if it were cold, has been practiced for a number of years. It is only recently, however, that this system has been applied to torpedoes, and this invention, patented by William Horace Sodean, of Newcastle-upon-Tyne, England, and assigned to the W. G. Armstrong, Whitworth & Co., the well known builders of torpedoes, is an improvement over certain former invention of his designed to accomplish the same purpose.

As described in the American Inventor, this device re-heats the compressed air by burning inside the reservoir alcohol, petroleum, or other combustible liquid, thus raising the temperature of the air and consequently increasing the volume which the compressed air will have at a given pressure.

In the practical application of this discovery it was found, however, that the rate of feed of the combustible liquid to the air reservoir increased very greatly as the pressure decreased and that consequently dangerously high temperatures were likely to be produced in the latter stages if the combustible liquid was fed at such a rate as to produce a rapid rise of temperature. It was in order to regulate the rate of feed that the invention shown herewith was devised.

According to this invention the progressive feeding of the combustible liquid into the air reservoir is dependent upon the fall of pressure in the latter. This is secured by extending the pipe connecting the fuel reservoir with the air reservoir, upwardly through the former, through the whole or a considerable portion of the vertical height thereof and in giving said pipe two or more openings of different heights permitting communication between the interior of the pipe and that of the vessel.



When the level of the combustible liquid has fallen sufficiently to expose one or more of these openings, the air confined in the air space of the fuel reservoir will begin to pass through the exposed opening, while the combustible liquid will continue to flow through those openings which remain submerged. The rate of feed will thus be diminished at the moment at which one of these openings is disclosed. The air space will increase to a less extent for a good reduction of pressure than it would have done had no air been allowed to escape from the fuel reservoir. Consequently the continuance of the discharge from the air vessel will not increase the rate of feed and the successive exposure of other openings in the fuel feed pipe will continue to check such rate.

The operation of the apparatus is as follows: As soon as the torpedo engine is started the pressure in the air reservoir naturally begins to fall and in consequence, the air in the space in the combustible reservoir expands, thereby driving the liquid through a spraying nozzle so that it enters the compressed air reservoir in a condition for rapid combustion. This spray is ignited by the firing of a primer and the fuel burns fiercely in the compressed air. Thus this expanded hot air is supplied to the engine through the pipe leading to the compressed air chamber. As the combustible liquid falls and exposes the holes in the exit pipe, air will pass through the exposed hole, but the combustible liquid continues to flow through those which are submerged. This passage of air reduces the stream of combustible liquid and also lessens the growth of the air space above it, thereby decreasing the rate at which the feed increases.

UNNECESSARY LOSS OF LIFE IN THE NEW YORK TUNNELS*

By R. W. Raymond.

In the *Journal* of June 2, 1906, I published an article on "Blasting in New York City," calling attention to the dangerous character of the method of rock-excavation commonly pursued by contractors in the tunneling now in progress under this city. My protest has received fresh emphasis from the recent loss of several lives, as a direct result of the system I condemned.

As I explained in the article referred to,† the usual present procedure is to drill deep converging holes in the face of the tunnel, explode in them heavy charges of dynamite, and thus produce an irregular cave, with shattered sides and roof. After removing the displaced rock, the desired section of the tunnel is perfected by further and less violent operations. This method is unquestionably objectionable from an engineering point of view, because it leaves the rock outside of the tunnel section more or less fissured. It is objectionable also by reason of the annoyance and injury which it inflicts upon overhead buildings and their occupants. And to these grounds for its condemnation, we must add the further consideration that it is unnecessarily dangerous to workmen. The cave produced by violent large blasts must be entered, in order to remove the fallen and the loosened rock. During this operation there is great danger of the fall of part of the shattered roof. The work is consequently recognized as extra-hazardous, and men of special skill and courage are employed in it, and receive high wages on account of the risk they assume.

Thus, the other day, a workman who "knew no fear" and received on that account $7 per day, was killed by a fall of rock in one of the caves created by big blasts in a New York tunnel; and other lives, not thus paid for beforehand, were similarly sacrificed.

It cannot be too strongly declared that all this danger and destruction is unnecessary. It is perfectly practicable to run a rock tunnel by drilling a vertical centre cut, and blasting with light charges in holes parallel thereto, so as to avoid injury to persons or property, or even the annoyance of miniature earthquakes, now suffered by New York citizens whose lodgings are undermined by the progress of subterraneous public improvements.

I have recently heard from transient guests at the Waldorf-Astoria, and from permanent residents of that part of the city, vigorous complaints of the shocks received from tunnel blasts. Such parties are hereby notified that I cannot help them, except by publicly declaring, once more, that the nuisance of which they complain is wholly unnecessary. I do not even believe that the quieter and safer method of tunneling would be more expensive, if it were carried out with intelligence, and with loyalty on the part of subordinates and workmen.

But it is useless to argue that proposition, so long as specifications in contracts do not require the reform, and contractors are unwilling to introduce it, at the risk of a quarrel with labor. The only immediate remedy I can perceive is public opinion, such as is created by much talk, and especially by writing to the papers. Let my aggrieved friends say in these ways what they vainly say to *me*, and something may come of it! For instance, juries may be led to grant heavier damages against contractors who persist in employing a method involving unnecessary risk of injury to person and property, and official boards may hereafter require of contractors the use of the safer method. More-

*Abstracted from Engineering and Mining Journal.
†See Compressed Air, August, 1906.

over, if the sufferers should make noise enough, even the present contractors may be scared into mending their ways. So, my advice to my correspondents is: Go on, and talk and write as often and as much as you can—only not to me!

CHEAPER LIQUID AIR

Reduced cost of liquid air production is indicated by an article in the London *Times*. Recent experiments in England of an invention by Mr. Knudsen, a Dane, furnished liquid air at one-sixth of the present market price, and give promise of an ultimate low price of a fraction over two cents per gallon. The result is secured by purely mechanical means, without an atom of added chemicals. Atmospheric air is first purified and then compressed by stages to 2500 pounds to the square inch. It is finally reduced to 125 pounds to the square inch, which then cools and liquefies the high-pressure air.

The oxygen gas produced by separating the nitrogen from the liquid air is claimed to be purer than by the old method, and can be supplied in the liquid as well as the gaseous form. One gallon of liquid air equals approximately 128 cubic feet of oxygen gas, which retails at six cents a cubic foot. The new price is one cent. Liquid air has been successfully used in coal mines as an explosive, being quite safe where fire damp and other explosive gases exist. Liquid oxygen is also used for welding steel pipes, boiler shells, and plates for shipbuilding instead of riveting.

That oxygen and nitrogen can be separated from liquid air and sold retail at $1.20 a gallon shows great commercial possibilities. The use of nitrogen for agricultural purposes opens yet another field. The maturing of liquors will be helped by liquid air, as also the preservation and purification of milk. As a motive power its use is considered to be quite practicable for small powers. The British government is already carrying out a number of experiments with a view to the utilization of liquid air for various purposes.

EXTRUDED METAL

One of the many interesting exhibits at the recent convention of the American Railway Master Mechanics and Master Car Builders, says *Cassier's Magazine*, was the product known as extruded metal, formed by the pressing of hot metal through a die, thus forming a great variety of intricate and fancy shapes adapted to many uses in car and locomotive construction.

The word "extrusion" accurately describes the operation by which the various sections are formed. A billet of brass is first cast of a convenient size and suitable composition for the purpose intended. This billet is re-heated until it is of a plastic consistency, and then, by means of a small crane, it is placed within a very strong horizontal cylinder or "container," at the front end of which is the die. Upon hydraulic pressure being applied at the rear end of the container, the plastic metal is forced or squirted through the die, issuing from it in a long bar having a cross-section corresponding to the section formed in the die.

The very high pressure (oftentimes as high as 60,000 lbs. per sq. in.) to which the semi-plastic metal is thus subjected gives it increased density and makes it perfectly homogeneous and free from possible casting defects. The bars produced by this process have a greater strength and tenacity than those made by rolling or other cold working methods, and for special purposes alloys are made having the requisite strength and elongation for work demanding the strength of good quality steel. It is also obvious that sections which cannot possibly be rolled or drawn can be made by the extrusion process with great accuracy.

In addition to bars or rods of irregular cross-section, all stock sizes of round, hexagon, square, rectangular, half-round, etc., are produced suitable for forging and all engineering purposes.

A considerable use that has been found for this metal is in the form of moldings for architectural work. It is well adapted for use in large stores and office buildings, railroad stations, residences, etc., and can be oxidized to give it any color desired.

THE "shell," or jacket guides, of a rock drill, when worn, allow the machine too much play, which is likely to break the feed screw and considerably affects the efficiency of the machine, inasmuch as it will waver slightly, each blow of the drill increasing the friction and thus reducing the efficiency.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

W. L. SAUNDERS, M. Am. Soc. C. E., . Editor
W. R. HULBERT, M. E., Assoc. Am. Soc M. E., Managing Editor
P. F. KOBBÉ, JR., . . Business Manager
F. J. ROHDE . . . Advertising Manager

PUBLISHED BY
THE KOBBÉ COMPANY,
90-92 West Broadway,
New York.

Subscription, including postage, United States Canada and Mexico, $1.00 a year. All other countries $1.50 a year.. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 90-92 West Broadway, New York.

London Office, 114 Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York, N. Y., Post Office.

Vol. XI. JANUARY, 1907. No. 11.

THE WATER PUMPING PLANT AT JAMECO, L. I.

The daily newspapers have been devoting considerable space to a discussion of the water-pumping plant which Mr. Silas W. Titus has installed at Jameco, L. I., on account of the unique contract which he had made with the city concerning the water supply of Brooklyn. This contract involved the taking over of the management of the pumping plant, providing the city with its ordinary quota of 1,400,000 gallons of water per day, but for all the water delivered to the city above this quota he was to receive $40 per million gallons. This price was to run for four months after all the wells were in operation. After four months, and for the balance of time, twenty months, he was to receive $30 per million gallons and, if he stopped at the end of four months, the contract was to be terminated, but if he continued, it was agreed that he should put up a permanent pumping plant at his own expense, which was to become the property of the city at the end of the twenty months.

Mr. Titus now has his plant in operation and the results achieved thus far appear to be exceedingly satisfactory, both to Mr. Titus and to the city; although, to our minds, not so unusual as the newspaper reporters would lead one to believe. Mr. Titus has increased the output of the twenty-one wells comprising the plant from 1,400,000 gallons per day to 8,400,000 gallons, which, on the face of it, would appear to be a most exceptional increase. But, without desiring to disparage Mr. Titus' achievement, it must be remembered that this only amounts to an average of 278 gallons per minute from each well, while the air-lift system, which is the system of pumping that Mr. Titus has installed, has frequently shown a capacity considerably in excess of this amount. The total amount, however, is a very large yield for one particular district, and if Mr. Titus succeeds in increasing this yield, which he seems to have every prospect of doing, he will be entitled to a great deal of credit for his foresight and engineering ability.

The success of the air-lift system at Jameco brings out more strongly than ever the chief points of merit which have long been claimed for this method of pumping, namely, that the system is only limited by the capacity of a well to yield water, it having been demonstrated that it will not only pump all the water which a well will deliver, but will actually increase the capacity of a well with service, owing to the fact that it tends to clean out the well and to keep it clean, thus permitting of a more ready inflow of water.

We wish Mr. Titus all success with his undertaking and trust that he will achieve even better results in the future.

THE NEW PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

It will probably be most welcome news to members of the American Society of Mechanical Engineers and to engineers in general to know that Prof. Frederick Remsen Hutton has been rewarded for his long and very efficient service as secretary of the society by being elected to the presidency. As was pointed out in this paper some time ago, Prof.

Hutton resigned the secretaryship owing to the fact that he considered it necessary to devote more of his time to his duties as Professor of Mechanical Engineering at Columbia University.

Prof. Hutton was born in New York City, May 28th, 1853, and after a preparation in a private school, entered Columbia College, receiving the degree of A. B. in 1876. He then entered the School of Mines, taking its degree in the same year. The next year he was appointed an instructor in mechanical engineering, serving under the late Prof. W. P. Trowbridge. He entered the faculty as an adjunct professor in 1881 and became full professor in 1890, which position he has held ever since.

When Columbia moved from 49th street to its present site on Morningside Heights, Prof. Hutton was called upon to take charge of the erection and equipment of the mechanical engineering laboratories which now stand as a splendid monument to his achievement. It would be difficult to find mechanical laboratories more completely equipped than those at Columbia. This equipment includes a Reynolds triple expansion steam engine of 150 H. P., a Baldwin-Vauclain compound express locomotive of 1600 H. P. mounted on friction wheels, equipped with brakes and dynamometers in order that it may be tested for tractive effort and general efficiency. Other unique apparatus which Prof. Hutton has added to the laboratory includes an Otis hydraulic elevator, many high powered steam pumps, numerous gas and oil engines and other apparatus which has served to make the laboratory one of the finest in the country.

Columbia has honored Prof. Hutton with the degree of Ph. D. and later, at its 150th anniversary, with the degree of Sc. D., which is the highest that it confers in the field of science.

Prof. Hutton has served as secretary of the American Society of Mechanical Engineers since 1883 and now becomes its president at a time when the society, having grown steadily in membership and influence, is about to occupy its quarters in the magnificent new engineering building rapidly nearing completion on West 39th street, New York.

AIR BRAKES FOR MOTOR CARS

In one of our editorials last month on this subject we made the following statement: "It is not necessary to use an air compressor for operating air brakes, as the pressure can be obtained from the motor cylinders. This is an important point, as one of the chief arguments against air brakes for use on motor cars has been that the air compressor absorbed a great deal of power; in fact, it has been estimated that the power required to operate the air brakes of a motor car would be approximately one-tenth of the power of the engine which, in the case cited, amounted to three and a half H. P."

Our data for the above statement was obtained from an article by Mr. Thomas J. Fay in a recent issue of "The Horseless Age." Our attention has now been called to the fact that the above statement is in error, and we are in receipt of a letter from Mr. E. J. Stoddard, of Detroit, Mich., pointing out the fact that instead of the air brakes requiring 3½ H. P. they would only require 0.3 H. P. as calculated in the following manner: Average pressure on piston, 25 lbs.; area of piston, 3½ sq. in.; stroke, 3 in.; number of strokes per minute 450; then H. P.$=\frac{(3\frac{1}{2})\,(25)\,(450)\,(\frac{1}{4})}{33000}$

$$=\frac{9900}{33000}=0.3$$

This puts the subject in an entirely new light and would tend to show that air brakes absorb but a slight amount of the power of the engine for their operation, and that they should, on that account, be received with more general favor by automobilists.

ATMOSPHERIC PRESSURE AS A STIMULUS TO CONVERSATION

Dr. Moorhead, of Washington, has recently reported to the Government with respect to some curious effects of rarefied and of condensed air on human respiration.

On high mountains some persons experience distressing "shortness of breath," on result of which they are unable to whistle. Precisely the same effect is sometimes produced by the condensed air in caissons and diving bells. Laborers working in compressed air frequently find, however, that their powers of exertion are increased as long as the atmospheric pressure is not more than double that of ordinary air; but beyond that point unpleasant effects are experienced after the men have left the working shafts and returned into the open air.

On the other hand, atmospheric pressure in the case of persons not doing manual labor has been found to act as a mental stimulus, increasing the impulse to talk.

Engineers in charge of the construction of the Pennsylvania tunnels assert that the safety appliances have reached such a state of perfection that the East River tunnels are now the best protected anywhere. The latest device is designed to keep workmen from being overcome by smoke in case of fire.

Formerly compressed air could come into an airlock only from the tunnel, and if the tunnel filled with smoke there was no way to get fresh air. Now a pipe connection is put in every lock so that fresh air can be let in by the mere turning of a valve. If smoke happens to collect in the tunnel the opening between it and the lock can be closed and the other pipe opened. In all four Pennsylvania Railroad tunnels under the East River at Thirty-fourth Street shields are now being pushed forward, both from Manhattan and Long Island City.

EVENING TECHNICAL COURSES AT COLUMBIA UNIVERSITY, NEW YORK

The board of extension teaching of Columbia University announces a series of nine evening technical courses which will be given at the university this winter, and lasting twenty weeks. The courses are under the immediate direction of Prof. Walter Rautenstrauch, of the Faculty of Applied Science, and are to be given by professors and instructors of the university and other persons especially qualified. Moderate fees ($7.50 to $15) are charged, and most of the courses are for two evenings a week. The courses are as follows:

Engineering Physics, as illustrated in the mechanical plants of modern buildings. (1) An elementary study of physics; (2) a practical study of steam and electrical machinery, heating, ventilating, water system, wiring, elevators, etc., included in the plant of Columbia University. For two classes of students: Those wishing an introductory study of physics as preparation to advanced study in electricity, steam, etc., another winter; those desiring practical training for positions as superintendents of buildings, engineers, janitors, etc.

Elementary Mathematics: Those parts of arithmetic, algebra, geometry and trigonometry used in technical work. Practice with engineering hand-books, tables, etc.

Drafting: A beginner's course; fits for positions as draftsmen; reading of drawings, etc.

Strength of Materials: A lecture course for those who design or manufacture machinery, or modern structures. With this course should be taken either the first or second of the two following courses in design.

Machine Design: Advanced drafting, computations, and designing for persons engaged in the design and manufacture of machinery.

Structural Design: Advanced drafting, computations, and designing for those who do structural work.

Electrical Engineering: A course especially for those engaged in electrical work of any sort.

Steam Engineering: A course for those engaged in the manufacture or management of steam machinery of any sort.

Special Engineering Problems: A study of any special elementary or advanced engineering problems desired by the student. Individual instruction will be arranged for such a period of time as the special problem may demand.

The courses will be given in the buildings of Teachers' College, Columbia University, at West 120th street and Broadway, which affords necessary lecture rooms, laboratories, drafting rooms, etc. A complete catalog of these courses will be sent on request by addressing Evening Technical Courses, Extension Teaching, Columbia University. Personal information may be secured Tuesday and Thursday evenings, between 7.30 and 9 o'clock, from Benjamin R. Andrews, Room 111, Teachers' College.

NEW PUBLICATIONS

Practical Lettering, by Thomas F. Meinhardt, being a series of plates with corresponding explanations for beginners, draftsmen, engineers, engravers, sign painters, stone cutters, lithographers, etc., with an original system for spacing, published by the Norman W. Henley Publishing Co., 132 Nassau Street, New York. Price 50c.

One of the most important characteristics of this work is the practical instruction which it gives on the subject of "spacing." This is

of particular value, as upon the correct spacing of a title depends to a great extent its appearance, and nothing will mar the looks of a drawing more than incorrect or careless spacing of the lettering, and this is, of course, of even more importance in the work of engravers, sign painters and stone cutters.

While Mr. Meinhardt's book contains only twenty pages, 14x9 inches in size, it is exceedingly complete and the explanations, hints for pen-work, hints on duplicating and analysis of construction, are all that could be desired, the remarks on spacing, of course, going into the subject in great detail.

For all those having need of a work on lettering we should think this book would be a great help.

Penberthy Engineer and Fireman, published monthly by the Penberthy Injector Co., Detroit, Mich., 34 pages, 6x9, 25 cents per year.

This little magazine contains many original articles which should be of interest to steam engineers and firemen, relating, as they do, to principles of heat and practical management of steam engines and boilers. We should think the publication more than worth the subscription price to those interested in steam engineering.

TRADE PUBLICATIONS

Ernst Wiener Company, 68 Broad St., New York.—Catalog No. 80, 24 pages, 6x9, printed in both Spanish and English and devoted to the subject of locomotives for industrial railways. Full particulars are given concerning each locomotive illustrated, the information being arranged in tabular form.

Ingersoll-Rand Company, 11 Broadway, New York.—Bulletin No. 2008, on Imperial Motor Hoists and Stationary Motors. The pamphlet contains a complete description of the Imperial Motor Hoist with illustrations and tables of sizes and dimensions. The later pages of the publication are devoted to illustrated part lists on each machine for the assistance of purchasers in ordering duplicate parts. The pamphlet is 6x9 in size and consists of 32 pages.

Catalog No. X-36, 44 pages, 6x9, devoted to a description and full particulars of the Imperial Type 10 Air Compressors. The catalog is handsomely illustrated and all information concerning compressors, receivers, etc., is placed in tabular form for ready reference.

Charles H. Besly & Co., 15-21 South Clinton St., Chicago, Ill.—60-page catalog, 5½x9, devoted to Besly Spiral Disc Grinders, Band Grinders and Helmet Spiral Grinding Circles. The catalog is exceedingly complete, well illustrated and contains considerable information of a practical nature regarding method of holding work, etc., for machinists.

De la Vergne Machine Company, Foot East 138th St., New York.—4-page folder, describing the Klein Water Cooling Towers for cooling the jacket water of gas engines and for use in power plants, breweries, ice plants, etc. These towers will cool the water to from 5 to 15 degrees below the temperature of the atmosphere.

Blaisdell Machinery Company, Bradford, Pa.—46-page catalog, 6x9, illustrating and describing all types and sizes of Blaisdell Air Compressors. This catalog is known as Bulletin No. 18 and contains full information on air compressors of from 4 cubic feet per minute capacity up to 529 cubic feet capacity. It also covers the subject of pneumatic stone tools, plug drills, surfacing machines, unloading devices, gas and gasolene engines and equipment for complete pneumatic stone plants.

Independent Pneumatic Tool Company, First National Bank Bldg., Chicago, Ill.—4-page leaflet, describing Thaw Piston Air Drills, Pneumatic Hammers, Portable Grinding Machines, Riveters and Wood Boring Machines.

Abenaque Machine Works, Westmintes, Station, Vt.—24-page catalog devoted to gas and gasolene engines of from 2 to 25 H. P., the principal advantage claimed for them being the fact that gasolene is admitted to the cylinder and no carburetter is required. This is a very important advantage, as it enables the engine to be started in cold weather without trouble.

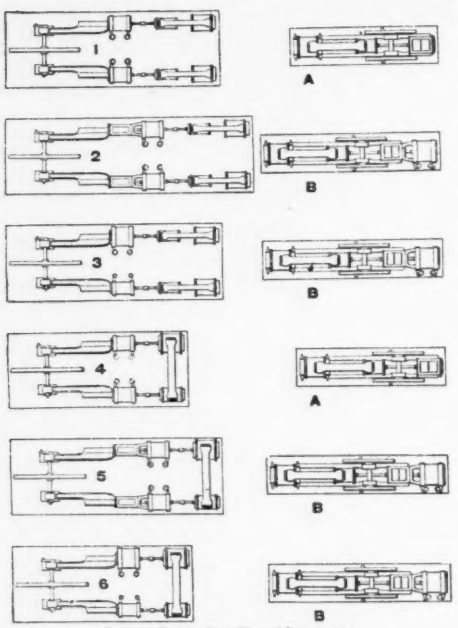
Sullivan Machinery Company, Railway Exchange Bldg., Chicago, Ill.—Mine and Quarry for November. This publication was reviewed in our columns when it first made its appearance and the November number, which is the third that has been issued, contains many articles which should be of interest to quarry men, mining superintendents and engineers in general. A particularly interesting article is one on drilling costs at a Newfoundland iron mine, which shows that proper methods of handling men and equipment may make the difference between loss and profit. Mine and Quarry is issued quarterly and will be sent to anyone on request.

INDUSTRIAL.

DUPLEX AIR COMPRESSORS

Under the impression that a duplex machine is easier to manipulate in starting or in slow running, some customers call for the duplex pattern. The supposed advantages do not exist when comparison is made with an up-to-date straight-line machine, and there are certain disadvantages which it is well for the buyer to know before completing a contract.

For any given output of air they are more



Diagrams Showing Floor Plans of Compressors.

expensive in first cost and up-keep, for there is double the machinery. There are double the chances of delays, for either side may be necessarily stopped and then all air is shut off until adjustments can be made to both machines, and a heated journal on either side stops both.

The generally observed friction of the duplex machines exceeds by about 5 per cent. the friction of two machines working separately.

For compound air compression duplex compressors are furnished in six varieties:

1st. Twin tandem compound air cylinders and twin simple steam cylinders.

2d. Twin tandem compound air cylinders and twin compound steam cylinders.

3d. Twin tandem compound air cylinders and cross-compound steam cylinders.

4th. Cross-compound air cylinders and twin simple steam cylinders.

5th. Cross-compound air cylinders and twin compound steam cylinders.

6th. Cross-compound air cylinders and cross-compound steam cylinders.

Of these patterns only the first two allow either side to be disconnected and the other side then runs as a complete machine.

The last four on the list are open to the objection that under no circumstances can one side be operated as a complete machine, for the cross-compound feature requires the operation of both sides at the same time.

The accompanying skeleton diagrams show floor plans of compressors of several kinds, all of the same capacity, and opposite each duplex machine is shown a straight-line machine for doing the same work at the same number of revolutions per minute.

Pattern A is a straight-line compressor with compound air end and simple steam end.

Pattern B is a compound air end and compound steam end.

These two patterns of straight-line compressors perform their work with the same steam economy as the corresponding duplex machine and do it with fully 5 per cent less internal friction.

The smallest duplex compressor occupies twice the floor space of the largest straight-line double compound compressor.

Foundations, engine rooms and piping adds expense in proportion to the floor space of the compressors.

As to the mechanism—by many it is thought that the term "complex" is a much more appropriate name than "duplex."

In the line of power-driven machines something can be said in favor of the duplex. In some exceptional cases of steam-driven machines there may be a debatable choice, but in the vast majority of installations the duplex has no advantages. The Norwalk Iron Works, of South Norwalk, Conn., can supply the compressors in single and compound steam patterns and in compound, three and four-stage air ends.

TRACING CLOTH NOW MADE IN AMERICA

Readers of COMPRESSED AIR will be interested in the fact that tracing cloth is now being manufactured in the United States. The domestic product is claimed to be equal in every respect to the imported cloth, having all the qualities a perfect tracing cloth should have.

The domestic tracing cloth is made by the American Tracing Cloth Company, having its offices at 11 Broadway, New York City, while the plant is located at Paterson, N. J. The cloth is sold under the name of Peerless. The company is believed to have accomplished quite a feat in succeeding in the manufacture of tracing cloth in this country, as many have tried to do so, but have not succeeded in producing a marketable article on account of

unfavorable climatic conditions characteristic of this country which they could not overcome.

The American Tracing Cloth Company has, however, succeeded in creating the conditions necessary for the manufacture of tracing cloth by special means which they guard carefully. It was also necessary specially to design the machinery with which tracing cloth may be made here, and the company holds several strong patents on these designs. The credit of discovering the process is due to a graduate of a German university, who is very prominent in his profession, while the machinery was designed by an experienced man who has had a long and successful career in textile work.

Strong financial interests are stated to be backing the company, and the managers are quite confident that their product will in time replace the imported article, when the consumer has found out that he can purchase a perfect tracing cloth made in this country and at a cheaper price.

THE Union Switch & Signal Co. has been awarded the entire contract for the interlocking and signaling of the great terminal station being constructed in Washington, D. C., by the Pennsylvania and the Baltimore & Ohio railroads. The installation will be electro-pneumatic, similar in its general characteristics to that in the railway yards of the Pennsylvania at the Union station in Pittsburg. The Washington installation, however, will be the largest and most complicated signaling and interlocking installation that has ever been constructed in the world. The largest one previous to this was put in service at St. Louis at the beginning of the World's Fair, and before that the most important was the electro-pneumatic interlocking system at the terminals of the Boston South station. Both of these plants were also installed by the Union Switch & Signal Company.

SELF-STARTING DEVICE

Of all the self-starting devices offered for use on motor cars one of the best was exhibited at the Automobile Show, Grand Central Palace, Manhattan, December 1 to 8. It comes from Chicago and consists of a reservoir of compressed air maintained constantly by the operation of the engine. When the engine has stopped the pressure remains constant until starting. Two of the cylinders are filled with compressed air, which turns the engine over, drawing the gasoline into the two remaining cylinders, where it is ignited in the usual manner.

It is stated that the general use of compressed air in boiler shops, which has largely aided in advancing boiler shop practice to the front rank in railway mechanical departments, is being extended in some shops to include the cleaning of crown bars and crown sheets with a sand blast. It is claimed that this gives much more satisfactory results than the old method of hammer and chisel. In a certain shop where the new method has been installed a dozen bars took a man ten hours under the discarded system, at a labor cost of $1.75. With the sand blast a bar is cleaned in 20 or 30 minutes, or about half the former time, and the job is a cleaner one when done. This same shop uses the blast with satisfactory results for cleaning the crown sheet as well.

LUBRICATION IN COLD WEATHER

An interesting argument in favor of graphite as a lubricant is put forward by the Dixon Crucible Company of Jersey City, N. J. It is claimed that almost any bearing that requires oil in it will work harder in winter than in summer, as the oil is bound to be more viscous when cold than when warm. It is for this reason that experienced men who have tried it suggest that a possible solution of difficulties in lubrication may be found in the use of flake graphite along with some thin mineral oil. The lubrication will be as good, if not better, and the drag and slowness will disappear.

THE Crandall Packing Company, Chicago, Ill., announce that owing to increased business their Cleveland office has been moved from 9 South Water Street to 805 Superior Street, N. W., in the Wade Building, where their stock has been greatly enlarged in order to enable them to take proper care of their stationary and marine business which is being handled from the Cleveland office. They also announce that their latest catalog is just off the press and will be forwarded to engineers upon request

FOR transmission of power in mines where compressed air is used, it has been found that, for general purposes, a moderate pressure of 6½ to 7 atmospheres is the best practice.

In drilling with machines it does not pay to overload an air-compressor with too many drills, or to use a main pipe so small as to reduce the air pressure materially. Experiments show that a drop of pressure from 75 to 45 pounds will reduce the length of hole drilled by more than 50 per cent. Great care should be taken to have no leaks in the pipe line, especially in the hose and couplings.

In the operation of air compressors the best results are obtained, it is said, when the areas of the suction and discharge valves are equal and of such proportions that the velocity of the air does not exceed 5,500 feet per minute. On a compressor run with a piston speed of 550 feet per minute, this requires a valve area equal to 10 per cent. of the piston area. The practice of making suction valve areas larger than those of the discharge valves is not advised as, while the incoming air is of greater volume, the discharge valves remain open for a very small proportion of the stroke.

Compressed air differs from electricity, especially in the fact that electrical friction losses cannot be regained, while corresponding losses with compressed air may be eliminated. The moderate fall in pressure in the air due to friction augments a loss of transmission. "If the air were at 80 lb. gage or 95 lb. absolute upon entering the pipe, and 70 lb. gage or 85 lb. absolute at the other end, there would be a loss of a little more than 10 per cent. in absolute pressure, but at the same time there would be an increase of volume of 11 per cent. to compensate for this loss of pressure, and the loss of available power would be less than 3 per cent."

VALUE OF TECHNICAL PAPERS

The advancing foreman of to-day must be up to new ideas and keep moving; he has no time to sit with his hands folded. The proper use of mechanical literature is the foundation of success. The good, energetic mechanic waits hourly for his mechanical journal to arrive; how would our minds be enlightened if it were not for this? We would never have anything before us that would give us any reason to improve or make improvement. Every month there is something new that is very beneficial to the mechanic, and, I am sorry to say, there is not one-half of the mechanics reading these papers that should be. The country has produced some of the finest graduates in the mechanical line, and it is these who are worrying their minds about modern mechanics and improvements that when published are beneficial to you and me. I think if every foreman would stop long enough to think where he is in this hustling, modern, improved mechanical world, he would subscribe for more mechanical literature.—*G. W. Keller, before the Convention of the International Railway General Foremen's Association.*

PUMPING WATER BY COMPRESSED AIR

The greater portion of the sugar factories in Louisiana, are to a great extent, dependent upon their water supply for condensation purposes, from deep wells.

These wells are usually of 4 to 10-inch piping sunk to a depth varying from 180 to 1,000 feet, according to location and water strata.

The usual practice is to use steam pumps and they do fairly well when large pumps, or enough of them are used, to help the pumps as much as possible. The water, after leaving the condensers, is circulated through a long ditch back to the supply pond in order to cool the water until repeated use compels us to turn it out to flow away.

A certain factory here has an 8-inch well 233 feet deep, but when these wells are sunk and water is struck, the water rises from within 10 to 20 feet of the surface. A large duplex pump was connected to the well and by working the pump to its utmost capacity, 250,000 gallons every 24 hours was the best it could do. As the factory wanted 500,000 gallons every 24 hours, the water had to be used several times and would be so hot that the required vacuum could not be maintained.

An air compressor of the flywheel type was next tried with results that settled the question then and there, as to the superiority of the air system over the steam pump. A receiver was placed between the pump and the well and a 1½-inch pipe was run to the well and down

to a depth of 165 feet. At the bottom was placed a very simple arrangement to discharge the air upward.

It required a little over 65 pounds air pressure to start the water flowing and then the pressure would drop to 60 pounds. One million gallons every 24 hours was discharged from the well. As only one-half of that amount was needed the compressors were run quite slowly.—*F. B. Dunning in the Engineers' Review.*

CHOOSING AN AIR COMPRESSOR

The following is some advice given by the *Record and Guide* to its readers on the selecting of an air compressor:

"Direct steam-driven compressors are generally more desirable, being entirely independent of engine or motor, shafting or belts, but special conditions frequently demonstrate the advisability of using a compressor driven by belt, gear or chain from electric motor, gas engine or other power, rather than by steam direct.

"When obtaining proposals upon steam-driven compressors, the steam pressure available at the throttle should be stated. If a power-driven compressor is contemplated, the horse-power available for operation should be considered in conjunction with the volume of air and pressure required to perform the desired service.

"When selecting an air compressor it is unwise to consider immediate needs only, for the introduction of a compressor is invariably followed by demands upon it not originally contemplated. Good practice suggests installing a compressor possessing a sufficient margin of reserve capacity to meet the additional needs that are sure to follow.

"After the required volume and pressure of air have been determined, the next consideration is to fix upon the size, type and make of compressor to be selected, and therein lies one of the most important features of the problem. A too frequent error is to regard low first cost as the primary consideration. The air compressor that is cheap in first cost sometimes proves more expensive in the end, through greater power consumption and frequency of repairs.

The list of air compressor manufacturers rate the free air capacity theoretically; in other words, the area of the cylinder is multiplied by the rate of piston speed, without allowance for the unavoidable losses in air compression due to heat, friction and clearance. The percentage of loss chargeable to these causes is naturally, directly dependent upon the efficiency of the air compressor, suggesting the inevitable conclusion, that the difference in first cost when invested in the most economical compressor earns a handsome interest, through the saving effected in reduced power consumption and general operating expenses.

"The comparative economy of air compressors is not as frequently investigated and determined as it should be. In a water pump or steam engine, decreased efficiency becomes readily discernible, but the deficiencies of an air compressor are not as promptly brought to view. Compressed air, if one would realize all the commercial economies and benefits that accrue, should be produced with the best machinery obtainable and utilized with the most improved equipment and appliances. For similiar reasons a second-hand air compressor, unless first repaired by a reliable maker, is rarely a wise purchase. Under any circumstances the suitability of a second-hand air compressor for the service intended should be carefully considered, especially as to its proper proportion for the air pressure required and (if steam driven) the steam pressure available."

HIGH pressure gas distribution by the Western United Gas & Electric Co. supplies 24 cities and towns west of Chicago, the population served being about 140,000, and the line fifty-two miles in length. The most interesting feature of the system is the concentration of all the gas manufacturing at Joliet, making all the other consumers in the district dependent upon the pressure lines. With an initial pressure of 50 lbs. per square inch at Joliet, the drop in the 8-in. main to Copenhagen, 16½ miles, is 10 lbs. From this point a 6-in. main runs to Aurora, 7½ miles, with a further drop of 10 lbs. From this point a line to Elgin consists of 5 and 4 in. pipes, the distance being 23 miles, and the resultant pressure barely enough for the distribution. It is proposed to introduce pumping machinery at Elgin, in order that the system may be still further extended, without the necessity for raising the initial pressure above 50 lbs.

Full specifications regarding any of these patents may be obtained by sending five cents to the Commissioner of Patents, Washington, D. C. (Stamps will not be accepted.)

832,791. ROCK-DRILLING MACHINE OR ENGINE. HENRY HELLMAN and LEWIS C. BAYLES, Johannesburg, Transvaal. Filed July 12, 1905. Serial No. 269,407.

Claim.—In a rock-drilling machine or engine, a rotatable power-cylinder having a side port at its forward end, a drill-steel slidably and non-rotatably held at said forward end of the power-cylinder, and having a passage extending longitudinally of said steel and communicating with the side port aforesaid, and a liquid-supply swivel loosely surrounding the forward end of the power-cylinder and having a port in communication with the side port aforesaid.

832,812. AIR-COMPRESSING APPARATUS. WILLIAM A. ROHR, Sorel, Quebec, Canada. Filed Dec. 11, 1903. Serial No. 184,821.

Claim.—In an air-compressing apparatus, the combination with a base, a weighted rotary member adapted to rest upon such base, and means for rolling the said member to and fro, of a cylinder, means pivotally supporting such cylinder below the surface of the said base, means for supporting the cylinder in an angular position facing the end of the base from which the member rolls, a piston movable in the cylinder, a piston-rod connected at one end to the piston, means yielding supporting the said piston with the opposite end of the piston-rod normally above the level of such surface and in position to be acted upon and depressed by the weighted member, the said cylinder being adapted to oscillate in a plane parallel to the direction of travel of the rotary member and move with the said member while the latter acts upon the piston-rod.

833,002. SYSTEM OF REGULATING FLUID-PRESSURES. FREDERICK ROBBIN, New York, N. Y. Filed June 21, 1905. Serial No. 266,265.

833,062. RELIEF-VALVE. WILLIAM F. KRICHBAUM, Newark, N. J., assignor, by direct and mesne assignments, to Foster Engineering Co., Newark, N. J., a Corporation of New Jersey. Filed Sept. 23, 1905. Serial No. 279,795.

833,079. PRESSURE-REGULATOR. WILLIAM O. MCCULLOUGH, Chicago, Ill. Filed Jan. 2, 1906. Serial No. 294,247.

833,087. SELF-REPLENISHING FLUID POWER-TRANSMITTER. PERCY F. RICE, Tustin, Cal. Filed Jan. 16, 1906. Serial No. 296,244.

833,093. AIR-VALVE FOR RADIATORS. HENRY M. STEVENSON, Perry, Iowa. Filed Aug. 2, 1905. Serial No. 272,426.

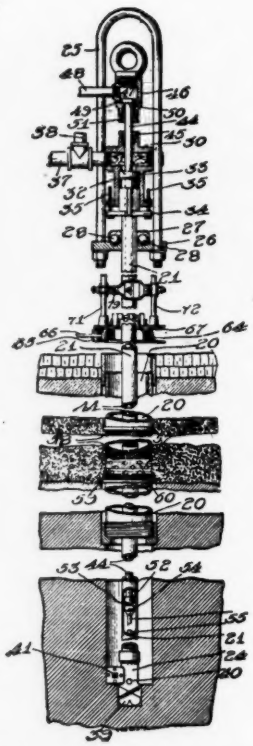
833,149. LUBRICATOR. GEORGE H. ANNAN, Providence, R. I., assignor to Jolt Lublicator Company, Providence, R. I., a Corporation of Rhode Island. Filed Nov. 1, 1905. Serial No. 285,411.

833,161. FLUID-PRESSURE BRAKE. RICHARD FITZGERALD, Chicago, Ill. Filed July 7, 1903. Serial No. 164,530.

833,200. WELL-SINKING APPARATUS. MATTHEW T. CHAPMAN, Aurora, Ill. Filed July 15, 1901. Serial No. 68,383.

833,201. WELL-SINKING APPARATUS. MATTHEW J. CHAPMAN, Aurora, Ill. Original application filed Sept. 25, 1899. Serial No. 731,507. Divided and this application filed Dec. 15, 1903. Serial No. 185,324.

Claim.—In a well-sinking apparatus, the combination of a swiveled head having an air-pipe connected therewith and extending down into the well, a swiveled well-tube through which said air-pipe extends, said air-pipe opening into the well-tube below the



level of the water, whereby the water and debris may be discharged from the well, means for rotating said well-tube, and a drill at the lower end of the well-tube, said drill being hollow and having openings for the admission of water to said well-tube, substantially as described.

833,206. AUTOMATIC RAILROAD-SIGNAL. JOHN P. EGAN, Milford, Mass. Filed July 18, 1906. Serial No. 326,739.

833,215. PEDAL ATTACHMENT FOR PNEUMATIC INSTRUMENTS. CHARLES H. HUBBELL, Derby, Conn., assignor to The Sterling Co., Derby, Conn., a Corporation. Filed Feb. 12, 1906. Serial No. 300,646.

833,234. PNEUMATIC-TIRE SHIELD. JOSEPH H. LOWREY, Neola, Iowa. Filed Sept. 26, 1905. Serial No. 280,111.

833,299. OIL-BURNER. ALBERT C. BUTLER, Crandall, Tex. Filed Oct. 6, 1905. Serial No. 281,667.

833,305. ELASTIC-FLUID TURBINE. CHARLES W. DAKE, Grand Rapids, Mich. Filed Nov. 29, 1905. Serial No. 289,654.

833,306. ELASTIC-FLUID TURBINE. CHARLES W. DAKE, Grand Rapids, Mich. Filed Nov. 29, 1905. Serial No. 289,657.

833,325. REFRIGERATING-MACHINE. WILLIAM C. HIESTER, Dayton, Ohio. Filed July 22, 1905. Serial No. 270,874.

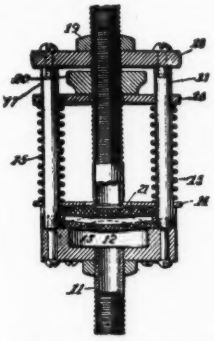
833,441. RIVETER. SAMUEL S. CASKEY, Philadelphia, Pa., and SAMUEL C. BOND, Wilmington, Del.; said Bond assignor to said Caskey. Filed April 4, 1902. Renewed March 16, 1906. Serial No. 306,347.

Claim—In a riveting device, a hollow rivet-set and plate-clamping device, a rivet-driving bar, means for operating said set to bring the same in proper position whereby said set clamps the plates, means for operating the bar independently of said set to form the rivet, and means within the clamping device for engaging the inner end of the rivet-set to limit the movement of said bar within the set and prevent its passage therethrough whereby the head is formed within the set.

833,568. CHANGE-MAKING MACHINE. JOSEPH N. WARNER, St. Paul, Minn. Filed Nov. 18, 1905. Serial No. 288,002.

Claim.—The combination with a fluid-pressure-distributing valve, of a bill adapted to be perforated to indicate the money received and the items of purchases, and change making and delivering mechanisms controlled by the flow of pressure through the perforations in said bill to discharge the desired change.

833,368. PRESSURE-REGULATED AIR-VALVE. ZENO C. BREWSTER, Oxford, N. Y. Filed June 20, 1905. Serial No. 266,184.



Claim.—In an air-compressor, the combination of an air-intake pipe having one end open toward the atmosphere, a valve adapted to move toward and from the open end of the intake-pipe and having one side subject to the pressure of the atmosphere, springs acting on the valve in conjunction with the atmospheric pressure, and a connection whereby the other side of the valve is subject to the pressure of the compressed air.

833,570. AUTOMATIC PRESSURE-RETAINING VALVE. ALONZO ASHCRAFT, Fort Smith, Ark. Filed Nov. 29, 1905. Serial No. 289,616.

833,702. AUTOMATIC FLUID-COUPLING. CHARLES H. TOMLINSON, Denver, Colo., assignor to The Tomlinson Coupler Company, Denver, Colo. Filed Sept. 22, 1905. Serial No. 279,623.

833,710. PNEUMATIC TOOL. NATHAN W. FLETCHER, Chicago Heights, Ill., assignor to Turbine Motor Tool Company, Chicago, Ill., a Corporation of Illinois. Filed May 20, 1904. Serial No. 208,981.

Claim.—The combination of a supporting-plate provided between its ends with a curved portion having opposite, parallel, concave and convex surfaces, a base-plate attached to the upper surface of said supporting-plate, a motor mounted on said base-plate, a tool-spindle mounted in said supporting-plate, driving means connecting the rotative member of the motor with said tool-spindle, a saddle-block having a concave surface adapted to fit the convex surface of said supporting-plate, and a clamping-bolt inserted through the curved portion of the supporting-plate and through said saddle-block.

833,938. CHANNELING-MACHINE. WILLIAM PRELLWITZ, Easton, Pa., assignor to The Ingersoll-Sargeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed April 1, 1905. Serial No. 253,248.

833,939. STRAIGHTWAY VALVE. WILLIAM T. RIDER, Coxsackie, N. Y. Filed March 10, 1905. Serial No. 249,424.

833,981. DETACHABLE PNEUMATIC TIRE. CHARLES S. SCOTT, Cadiz, Ohio. Filed Oct. 30, 1905. Serial No. 285,059.

833,992. AIR-BRAKE FOR AUTOMOBILES. ALEXANDER WINTON and HAROLD B. ANDERSON, Cleveland, Ohio, assignors to The Winton Motor Carriage Company, a Corporation of Ohio. Filed Aug. 10, 1905. Serial No. 273,631.

834,012. AUTOMATIC GLASS-BLOWING APPARATUS. FRED S. LEWIS, Port Allegheny, Pa., assignor of one-fourth to William J. Edgar, Port Allegheny, Pa. Filed Feb. 17, 1906. Serial No. 301,666.

834,067. SAND-BLAST APPARATUS. CHARLES A. LOUGHMAN and KARL HESS, Braddock, Pa. Filed Nov. 13, 1905. Serial No. 287,141.

834,116. SANDING DEVICE. JAMES W. FOIXEY, Newport News, Va. Filed April 21, 1906. Serial No. 313,060.

834,185. AIR-PRESSURE-SUPPLY APPARATUS FOR ATOMIZERS. CHARLES E. CAMPBELL, Ashland, Ohio, assignor to The Faultless Rubber Company, Akron, Ohio, a Corporation of Ohio. Filed Feb. 13, 1906. Serial No. 300,890.

834,343. AIR-BRAKE APPARATUS. WALTER V. TURNER, Wilkinsburg, and EDWARD A. WRIGHT, Edgewood Park, Pa., assignors to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Feb. 17, 1905. Serial No. 246,025.

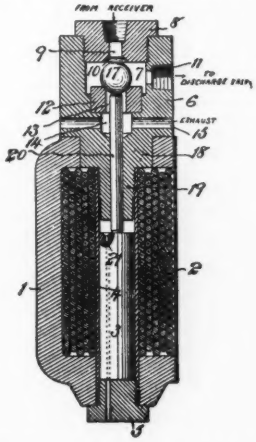
834,344. FLUID-PRESSURE BRAKE. WALTER V. TURNER, Wilkinsburg, Pa., assignor to The Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Aug. 22, 1903. Renewed March 15, 1906. Serial No. 306,260.

834,441. ROCK-DRILL. THOMAS E. ADAMS, Cleveland, Ohio. Filed July 29, 1905. Serial No. 271,806.

Claim.—In a drill, the combination with a barrel, of a drive-piston in the barrel, a driven piston in the barrel, and manually-controlled means for maintaining air at proper density between said pistons and similar means for maintaining the air at proper density on the opposite sides of the pistons to compel the driven piston to move with the driver.

834,522. ROCK-DRILLING MACHINE OR ENGINE. HENRY HELLMAN and LEWIS C. BAYLES, Johannesburg, Transvaal. Filed Jan. 11, 1905. Serial No. 240,661.

834,626. UNLOADER FOR SINGLE-ACTING COMPRESSORS. FREDERICK VAN DUZER LONGACRE, New York, N. Y., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Nov. 23, 1904. Serial No. 234,011.



Claim.—An air-compressor, a discharge-valve therefor and an unloader comprising a valve-box, its chamber having a pressure-supply port, a discharge-valve port in communication with the back of the discharge-valve, and an exhaust-port, a valve arranged to alternately open and close communication from the pressure-supply port and the exhaust-port to the discharge-valve port and electrically-controlled means for operating the valve.

834,641. PNEUMATIC HAMMER. CONRAD PRUNER, Wiener-Neustadt, Austria-Hungary. Filed Dec. 29, 1903. Serial No. 187,050.

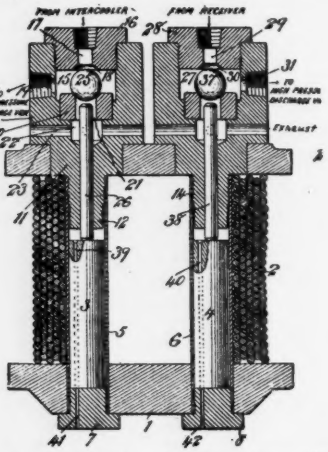
834,837. AIR-BRAKE BLEEDING-VALVE. HERBERT A. MINER, Logansport, Ind., assignor of one-half to Charles P. McCaffrey, Logansport, Ind. Filed June 12, 1906. Serial No. 321,417.

832,653. ELECTRICALLY-DRIVEN [illegible] N. Y. MOTOR. GASTON A. BRONDER, Brooklyn, Filed Feb. 12, 1903. Serial No. 143,134.

834,937. AIR-STRAINER. FRANK ROBINSON, Bangor, Me., assignor to The Robinson Company, Bangor, Me., a Corporation of Maine. Filed March 12, 1906. Serial No. 305,520.

834,997. DUST-REMOVER AND AIR-PURIFIER. RICHARD J. RADIKE, St. Clair, Mich. Filed April 21, 1906. Serial No. 313,087.

834,627. UNLOADER FOR COMPOUND COMPRESSORS. Frederick Van Duzer Longacre, New York, N. Y., assignor to Ingersoll-Rand Company, New York, N. Y., a Corporation of New Jersey. Filed Nov. 23, 1904. Serial No. 234,012.



Claim.—A compound air-compressor, discharge-valves therefor and an unloader provided with a plurality of valve-chambers, each valve-chamber having a pressure-supply port, an exhaust-port and a discharge valve port in communication with the back of one of the discharge-valves, a valve for alternately opening and closing communication from the pressure-supply port and exhaust-port to the discharge-valve port and electrically-controlled means for operating the valves.

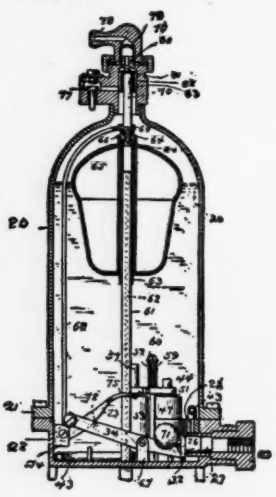
835,005. WHEEL-TIRE. Arthur S. Allen, Brookline, Mass. Filed March 6, 1905. Serial No. 248,466.

835,184. GATE. William P. Elliott and William P. Elliott, Jr., Chicago, Ill. Filed Aug. 27, 1906. Serial No. 332,218.

835,247. SHOCK-ABSORBER. Charles Morgan, South Orange, N. J. Filed Jan. 11, 1906. Serial No. 295,605.

835,261. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa, assignor to The Hardsocg Wonder Drill Company, Ottumwa, Iowa. Filed Aug. 12, 1905. Serial No. 273,930.

835,291. AUTOMATIC AIR-COMPRESSOR. John Rogers, Bridgeport, Conn. Filed Nov. 6, 1905. Serial No. 286,037.



Claim.—An air-compressor comprising a cylinder having induction and eduction connections and induction and eduction valves, a pipe leading from the induction-valve, means whereby fluid in said pipe will actuate the eduction-valve, a float and intermediate connections whereby when the cylinder is filled the induction-valve is closed and water permitted to pass through said pipe to open the eduction-valve, and when the cylinder is emptied the induction-valve is opened and the eduction-valve drained through said pipe and induction-valve and permitted to close.

835,391. WATER-ELEVATING APPARATUS. Frank Allison, Chattanooga, Tenn. Filed Nov. 25, 1905. Serial No. 289,093.

Claim.—A water-elevating apparatus comprising a pair of tanks having check-valved supply and discharge connections at their lower ends, a source of compressed-air supply, a chest communicating therewith and with the upper portions of the tanks, a piston-valve operated in said chest to alternately control the supply and exhaust of air to and from the tanks, air-feed pipes communicating with the source of air-supply and leading into the upper portions of the tanks, vent-pipes, combined air feed and exhaust pipes leading from the source of air-supply to the respective ends of the chest, valves connecting said pipes and each having an oscillatory valve member adapted in one position to connect the air-feed pipes with the combined air feed and exhaust pipes and in another position to connect the latter-named pipes with the vent-pipes, levers centrally pivoted to the stems of said valve members, a weight connected to one end of each lever, a bucket disposed in each tank, and a connection between said buckets and the other end of the lever.

835,442. AIR-RELIEF FOR LIQUID-RECEPTACLES. Lewis Landau, San Francisco, Cal., assignor to Landau Economic Siphon Company, San Francisco, Cal., a Corporation of California. Original application filed Dec. 7, 1905. Serial No. 290,739. Divided and this application filed May 31, 1906. Serial No. 319,641.

835,467. ENGINEER'S VALVE. William K. Rankin, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Jan. 3, 1906. Serial No. 294,379.

835,468. ENGINEER'S VALVE. William K. Rankin, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Jan. 30, 1906. Serial No. 298,693.

935,589. PNEUMATIC TOOL. Wells Wheeler, East Pittsburg, Pa., assignor of one-half to Frank W. Chattin, Butte, Pa. Filed Dec. 23, 1905. Renewed Oct. 3, 1906. Serial No. 337,277.

Claim.—In a percussion implement, the combination of a tool-actuating cylinder, a piston therein, a compressing-cylinder and piston therein, connections between said cylinders, a by-pass connecting the ends of the compressing-cylinder, and valve mechanism arranged to keep said by-pass open during a predetermined number of reciprocations of the compressing-piston and close the same during the next reciprocation of said piston.

835,775. PRIMARY PNEUMATIC VALVE. George P. Brand, New York, N. Y. Filed Jan. 31, 1905. Serial No. 243,464.

835,774. AIR TENSION-MOTOR. George P. Brand, New York, N. Y. Filed Jan. 15, 1904. Serial No. 189,101.

835,776. TRACKER-BAR FOR PNEUMATIC PLAYERS FOR MUSICAL INSTRUMENTS. George P. Brand, New York, N. Y. Filed Feb. 23, 1905. Serial No. 246,865.

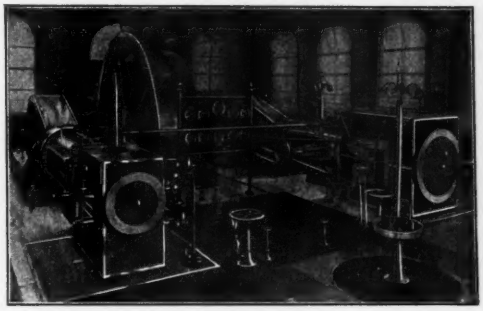
835,777. MEANS FOR AUTOMATICALLY CONTROLLING PNEUMATICALLY ACTUATED DEVICES. George P. Brand, New York, N. Y. Filed Jan. 16, 1906. Serial No. 296,313.

835,778. PNEUMATIC VALVE-SEAT. George P. Brand, New York, N. Y. Original application filed Jan. 13, 1905. Serial No. 243,463. Divided and this application filed Feb. 10, 1906. Serial No. 300,432.

835,782. PNEUMATIC FAN. John H. Creveling, New York, N. Y., assignor to Safety Car Heating & Lighting Company, a Corporation of New Jersey. Filed Nov. 18, 1901. Serial No. 82,716.

835,808. TIRE. Henry T. Bragg, Yonkers, N. Y. Filed Jan. 16, 1906. Serial No. 296,260.

COOPER-CORLISS ENGINES



FOR ALL POWER PURPOSES

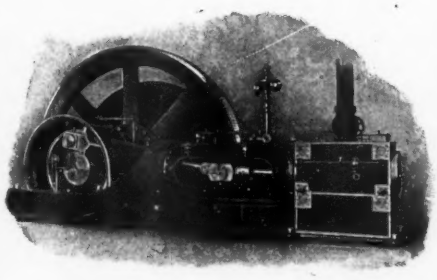
Complete Plants a Specialty

EXCELLENT FACILITIES FOR HANDLING EXPORT TRADE

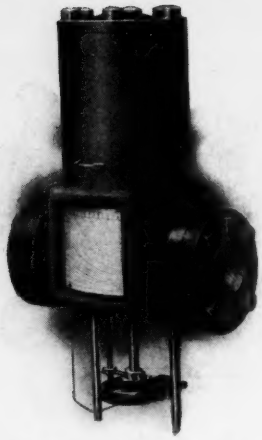
ESTABLISHED 1833

The C. & G. COOPER COMPANY

MT. VERNON, OHIO, U. S. A.



NEW YORK,	1430 Bowling Green Building
BOSTON,	411 Weld Building
PHILAPELPHIA	Drexel Building
PITTSBURG,	604 Frick Building
ATLANTA,	310 Chandler Building
CHARLOTTE, N. C.	South Tryon Street



The Sargent Compressed Air and Steam Meter is the only instrument on the market that will absolutely indicate the cubic feet of free air or the pounds of steam flowing through a pipe irrespective of the pressure. It is an instrument of precision guaranteed to be accurate within 2 per cent. Write for catalogue.

SARGENT STEAM METER CO.,
1326 First National Bank Building,
CHICAGO, U. S. A.

AIR COMPRESSOR LUBRICATION

This new Dixon booklet points out the dangers in the present system of lubrication in air compressors, and explains how to minimize or do away with these dangers entirely.

Crisp, fresh information in attractive form.

Write for free copy 188-V.

Joseph Dixon Crucible Co.

JERSEY CITY, N. J.

CLEVELAND
PNEUMATIC TOOL CO
CLEVELAND
OHIO
U.S.A.

Drills Chippers
RIVETERS

Most POWERFUL Tools
ON THE MARKET
BOWES HOSE COUPLING

INSTANTLY CONNECTED NEVER LEAKS
CATALOGUE "G" MAILED ON REQUEST

SAND BLAST MACHINERY

At 30 lbs. pressure compressed air drives the SAND BLAST

It gives you the cleanest casting at the lowest cost

It does all your work quickly and thoroughly.

WRITE FOR CIRCULAR which will tell you all about it

J. W. PAXSON CO.

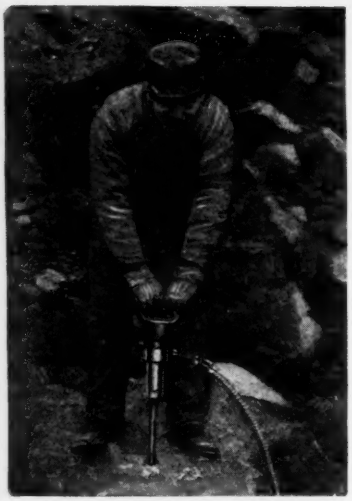
Foundry Supplies and Equipment

PHILADELPHIA, PA.

INDEX TO ADVERTISERS.

The "LITTLE IMP" and "LITTLE JAP"

HAMMER DRILLS



The "LITTLE IMP" on a down hole.

Economy in air consumption is as essential in the hammer drill as in the heavier rock drill. Ingersoll-Rand hammer drills, like the Company's standard rock drills, have a higher air economy than any other types, resulting in a 25 to 40 per cent. fuel saving for a given number of drills, or enabling a given compressor to run a correspondingly greater number of drills. Combined with this greater air economy are a greater drilling capacity and a greater endurance, making these machines the standards of commercial economy in drills of their type.

The "Little Jap" using air feed attachment in a mine.

The "Little Imp" Hammer Drill is supreme in the "valveless" class. It has but one moving part, resulting in extreme simplicity. Both piston and cylinder are hardened and ground—an exclusive feature resulting in the practical elimination of all wear.

The "Little Jap" Hammer Drill is the standard in the "valve" class. Its improved valve movement gives it a more rapid, powerful blow than any similar type. Unique design and specially treated materials give it an endurance practically eliminating repairs.

INGERSOLL-RAND CO.,

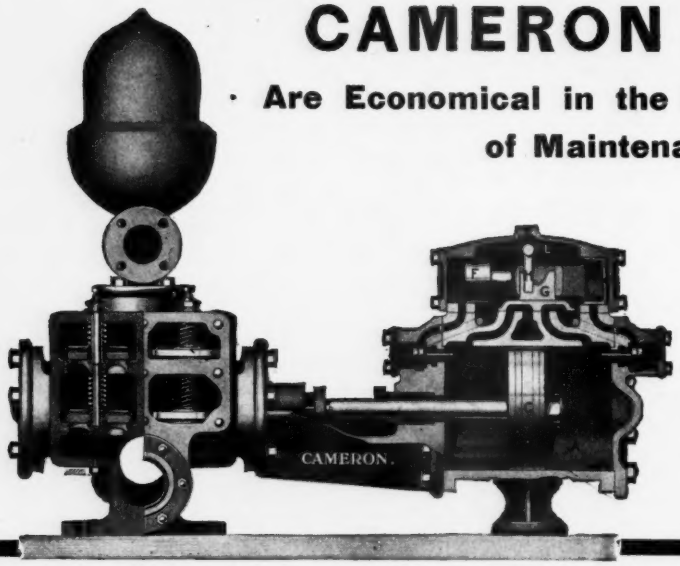
Chicago, Cleveland, Birmingham, Berlin, Philadelphia, Houghton, Mich., San Francisco, Johannesburg, **11 Broadway, NEW YORK**, Denver, London, Seattle, Paris, St. Louis, Pittsburg, Salt Lake, Melbourne, El Paso, Boston, Mexico City, Kalgoorlie

U 49

START THE NEW YEAR BY ECONOMIZING.

CAMERON PUMPS

Are Economical in the Best Sense, Cost of Maintenance.



This is a sectional view of a Regular Pattern Piston Pump for general service. *Equally* efficient with *Compressed Air as with Steam,*

Look at the construction.

Cameron Pumps are built for every service.

Every type of CAMERON PUMP possesses the CAMERON characteristics—ample weight of metal, few working parts and none of them exposed to external damage; reliability for either continuous or intermittent operation; normal or abnormal capacities, and small cost for maintenance or repairs.

To get a better idea of CAMERON characteristics—read our catalogue Edition "K," which will be sent to you on request.

Regular Pattern.

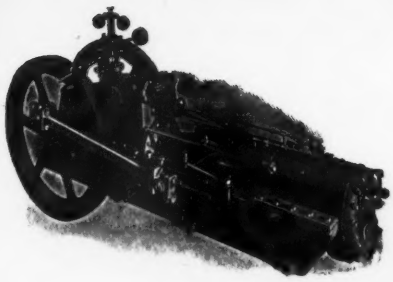
A. S. Cameron Steam Pump Works

FOOT OF EAST 23d STREET

NEW YORK.

The Slogan of the Cameron—

"Character: The Grandest Thing."



AIR COMPRESSORS

ALL STYLES—ALL SIZES

EMBODYING LATEST IMPROVEMENTS

ROCK DRILLS

McKIERNAN DRILL CO.

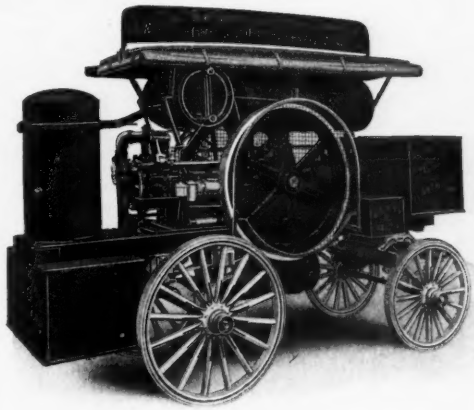
170 Broadway, New York City

House Cleaning Machinery

Stationary Private Plants for residences, **$350** and up. Power from lighting current.

Private Plants for Department Stores, Hotels, Theatres, etc.

Stationary Plants for Professional Carpet Cleaners.



Portable Plants for residential house cleaning. Small capital required.

General Compressed Air House Cleaning Co.

4434 Olive Street, St. Louis, Mo.

PATENTS

procured promptly and with care in all countries. Trade marks and copyrights registered.

DAVIS & DAVIS

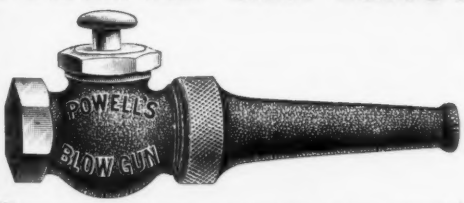
ATTORNEYS-AT-LAW

WASHINGTON, D. C.

220 BROADWAY, NEW YORK

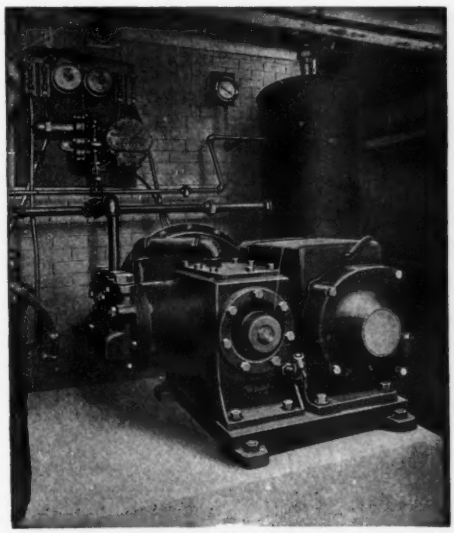
WHY NOT USE

Powell Air Gun Valve?



Blows your work bench, machine tool, in fact everything perfectly clean. Operation is another case of "Press The Button." Order a sample.

THE WM. POWELL CO., Cincinnati, Ohio.



Westinghouse Motor Driven Air Compressor, Operating Sewage System, Knickerbocker Trust Building, New York.

Westinghouse Air Compressors

Westinghouse Traction Brake Co.

General Offices : Pittsburg, Pa.

Address nearest office:

Boston, 638 Exchange Bldg.
Buffalo, 774 Ellicott Sq. Bldg.
Chicago, 1545 Ry. Exch. Bldg.
Cincinnati, 1111 Traction Bldg.
Cleveland, 1007 New Eng. Bldg.
Columbus, 1132 C. Sv. & Tr. Bldg
Denver, 604 Majestic Bldg.
Los Angeles, 527 So. Main St.
Mexico City, Mex., 434 Calle de San Diego.
New York, 2014 Trinity Bldg.
Richmond, 804 American Nat. Bk. Bldg.
St. Louis, 1932 North Broadway.
St. Paul, 634 Endicott Bldg.
San Francisco, 302 Rialto Bldg.

For Canada, Canadian Westinghouse Co., Ltd., Hamilton, Ont.

"Compressed Air"

PUBLISHED MONTHLY.

THIS is the only publication devoted to the useful applications of compressed air, and it is the recognized authority on all matters pertaining to this subject.

RATES OF SUBSCRIPTION.

United States, Canada and Mexico, per year, $1.00.
All Other Countries, $1.50. Single Copies, 10 Cents.

List of Books on Compressed Air.

Volume No. 10, "COMPRESSED AIR".....cloth **$2.00**
March 1905-February, 1906, inclusive. The twelve numbers "COMPRESSED AIR," which make up a summary of a year's events, including descriptions of important compressed air installations and applications, all well illustrated with fine half-tone engravings and line cuts.

"Compressed Air Information." Edited by W. L. Saunders.....cloth **5.00**
A cyclopedia containing Practical Papers on the Production, Transmission and use of Compressed Air.

"Pumping by Compressed Air." By Edward A. Rix.....cloth **.75**
A practical treatise on this subject, containing valuable information, with diagrams and tables. The different systems are described and compared, and the advantages of each impartially stated.

"Compressed Air." By Frank Richards .....cloth **1.50**
Contains practical information upon air compression and the transmission and application of compressed air.

"Liquid Air and the Liquefaction of Gases." By Prof. T. O'Conor Sloane, 350 pages.. **2.50**

Experiments on the Transmission of Power by Compressed Air in Paris, by A. B. W. Kennedy, F. R. S. M. Inst., C. E., Emeritus Professor of Engineering in University College, London. The Transmission and Distribution of Power from Central Station by Compressed Air, by William Cawthorne Unwin, B. S. C., F. R. S., M. Inst. C. E..... **.50**

"Electrician's Handy Book." By Prof. T. O'Conor Sloane, 800 pages..... leather **3.50**
A practical hand-book on electrical work for the engineer and non-technical man.

"Mechanics of Air Machinery." By Julius Weisbach and Gustav Hermann.....cloth **3.75**

"Tunneling." A practical treatise, by Charles Prelini, C. E., with additions by Charles S. Hill, C. E. 150 diagrams and illustrations .....cloth **3.00**

"Transmission of Power by Fluid Pressure. By William Donaldson, M. A., (M. Inst. C. E.).....cloth **2.25**

"Modern Machine Shop Construction, Equipment and Management." By Oscar E. Perrigo, M. E..... **5.00**

FORWARDED POSTPAID ON RECEIPT OF PRICE.

PUBLISHED BY

THE KOBBE COMPANY,

90-92 West Broadway, New York.